STATIC ELECTRICITY AND THE USES OF THE ROENTGEN RAY

SNOW

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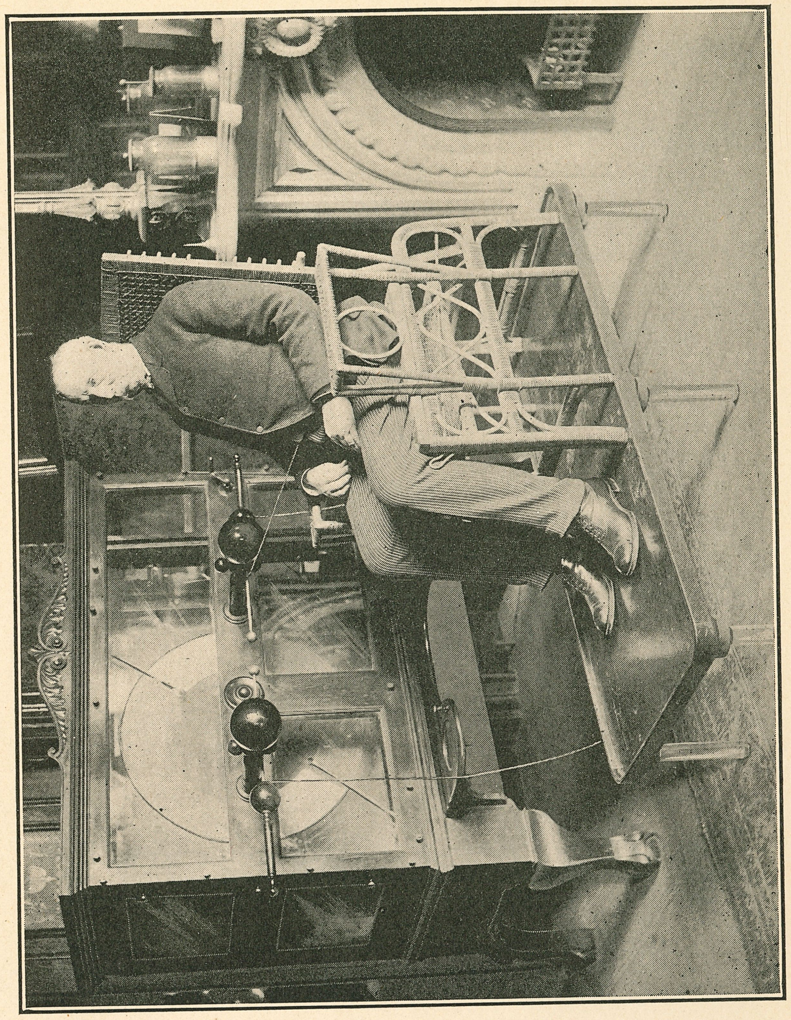

PLATE I.—Method of Administering the Wave-Current. A Metal Electrode (in the above Instance) Was Passed over the Abdomen, Connected with the Positive Side of the Machine and the Negative Side Grounded.

A MANUAL OF

ELECTRO-STATIC MODES OF APPLICATION, THERAPEUTICS, RADIOGRAPHY, AND RADIOTHERAPY

THIRD EDITION

BY

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PREFACE.

AFTER careful review of the literature treating of static electro-therapeutics, including comments and treatises of recent dates, the writer finds no work which will guide the practitioner first undertaking to operate a static machine in many important procedures. One only, Hedley, gives more than a suggestion of the most recent and most valuable of all forms of electrical administration—the Morton wave-current.

Hedley gives an outline descriptive of the method, but no allusion to its therapeutic value and indications. Others devote considerable space to the "static-induced," or what some choose to call the "Leyden-jar current," but lose sight of the most important current.

The writer's association with the ablest living authority on static electro-therapeutics, Professor William J. Morton, M. D., of New York, and familiarity with his work at the time the therapeutic uses of the "wave-current" were developed, afforded him an opportunity to make many experiments which have helped to demonstrate its great value. He feels justified, therefore, in adding to the present literature a practical work covering some of the gaps not filled in by others. It will be the aim of the writer to make clear, concise, and explicit all practical methods of administration, devoting as little space to pathology, diagnosis, and the study of disease as is deemed necessary to clearly define the course of treatment. Those who care to know more of the physics of static electricity are referred to the standard works on the subject.

WILLIAM BENHAM SNOW.

PREFACE TO SECOND EDITION.

THE first edition of this work, which had been prepared for publication in a serial, was written more than two years ago, and contained many imperfections. Care has been taken in the second edition to make such changes and corrections as will place the subject before the reader in a more concise style and include the later developments of the subject.

It was also the purpose of the first edition, when the work was undertaken, to include Skiagraphy. A section has been added to this work covering this subject and also one devoted to Radiotherapy.

These great subjects are still in a stage of development, and while it has been the author's effort to treat of them in a conservative and practical manner, he well realizes that in the future opinions will change as a consequence of the growth of a new science.

It is hoped that the readers, appreciating the necessity of continued investigation from the fact that there is much yet to be demonstrated, will accept the work in the spirit in which the writer has undertaken it and add their efforts to perfect and make widely known subjects of such value to the suffering.

At best, a work at this time can only mark the progress of the employment of electricity and the Roentgen ray.

W. B. S.

PREFACE TO THIRD EDITION.

The demand for the previous large edition of this work having exhausted the issue within a few months, the writer feels justified in publishing a third edition.

The short time since the publication of the last edition has created so few changes in methods that this one is essentially the same, except for a few alterations in definition and expression, together with the substitution of some cuts for others showing recent progress in apparatus.

The writer wishes to express his profound appreciation to the profession for many kind expressions which have greatly exceeded his expectations.

W. B. S.

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SECTION I.

ELECTRO-STATIC MODES OF APPLICATION AND THERAPEUTICS

SECTION I.

ELECTRO-STATIC MODES OF APPLICATION AND THERAPEUTICS.

CHAPTER I.

INTRODUCTION.

THE growing interest in the electro-static treatment of many forms of disease arises from the results obtained, in many instances so startling that to gain the credence of a confrère often requires that he witness the administrations; and of the operator that he have confidence in the veracity of the patient, and his own diagnosis. Many physicians themselves have proved excellent subjects for demonstration.

The development of this recognized valuable department of electro-therapeutics has advanced step by step with the evolution to perfection of the modern static machine. In England and on the continent of Europe, where at present no such machines are produced as the American apparatus, static electro-therapeutics is not advanced; and the physicians of this country who are wont to look abroad for advanced ideas are not likely to discover progress at home. In the recent writings of Hedley, Jones, and Bordier the subject receives but brief consideration, Jones acknowledging that the American machines are superior to others.

Since the introduction of electricity in medicine there have been progressive improvements in methods and the development of more perfect apparatus adapted to special applications and indications. The crude continuous current batteries, made without reference to size of elements or number or arrangement of cells, and having no means for regulating the current, have been succeeded by batteries designed for special uses, and

associated with rheostats for controlling and milliampere meters for measuring the current, thus enabling the operator to make intelligent and safe use of an agent capable of doing serious mischief.

With the same progress of the science marked changes in the character and utility of the induced-current battery have been evolved. The first crude affairs, having short, coarse secondary coils and indifferent means for interrupting, have been succeeded by the perfected apparatus, having long, fine wire secondary coils, and varied devices for fine, slow, or rapid interruptions. The perfecting of these forms of electrical apparatus has worked most striking changes from time to time in the medical mind. Principles have been set up based upon some theory of an authority, to be later disproved. Gradually the peculiar polar effects of the constant current have become established, and electrolysis, cataphoresis, and cauterization have become its chief fields of usefulness. Little is it valued to-day as an anodyne, tonic, or reconstructive alterative, in which induced current has superseded it; only to be superseded by more effective currents. Apparatus have been produced generating currents of greater and greater voltage and relatively very small amperage, and results obtained have led on to the introduction of new and more perfect machines.

The relative merits of currents and the uses of various apparatus should be briefly considered in passing, as the body of this work will deal exclusively with static administrations. We believe that in most cases not calling for the peculiar polar actions of the constant current, the static currents, when they can be administered, are to be preferred. The great point of superiority characteristic of the static wave-current lies in the fact that it is an oscillating *one-pole* current (always of one polarity) of high or low potential, and great or moderate frequency, under perfect control, painless during administration, and of such small quantity as to never endanger the life of the patient. The patient, being insulated, is repeatedly charged and discharged, synchronously with the interruptions at the spark-gap from the surface of contact with the electrode, producing local effects, and at the same time the constitutional

effects peculiar to currents and other modalities administered from one side of a source of high-potential electrical energy.

The static-induced current, which has received much more recognition because it has been longer known, is of relatively little value, and the writer knows of few indications for its substitution for the wave-current. *Static sparks, brush-discharge, breeze and static insulation* each meet valuable indications, and all partake of the characteristic of the wave-current,—they are administered with the patient insulated, and are often called currents, though they are not in the technical sense of the term, the resistance of the dielectric permitting the body to become charged before it escapes.

The currents of great frequency and high potential of the apparatus of d'Arsonval are currents from transformers produced by means of Leyden jars and condensers and are in connection with dynamo currents often of relatively large amperage, and are not safe when administered in currents having great voltage. The therapeutic effects, while surpassing all but the static currents, accomplish nothing that they do not, and fail absolutely where the latter succeed. The apparatus is elaborate, expensive, and for the reasons above stated, adds little to the armamentarium of the physician who has a static machine.

The current generated by the sinusoidal machine, adapted only to sanitarium or office practice, because it is not portable, does not approach in value the d'Arsonval currents, but gives generally better results than the faradic. The current is of relatively low voltage and greater amperage than the induced current, and is also a more agreeable current. It has no advantage, however, over the wave-current, and will rarely be called into requisition when the static machine is at hand.

The induced current, while a relatively feeble agent, will be of service at the bedside or home of the patient, where in but rare instances it will be possible to have more elaborate apparatus present. If an induced-current battery is expected to be of service except for purposes of stimulation it should have not less than 1500 yards of fine wire in its secondary coil, and be provided with a fine ribbon or other device for rapid

interruption. When we consider the marked improvement in these instruments over the ancient ones, and take note how greatly inferior they are to other apparatus, it is not surprising that electricity has so often proved disappointing, or that the mass of the medical profession are skeptics.

The discovery of the Roentgen ray, followed by the prompt adaptation of the static machine to its production, has given Franklinism another field, which is bound to redound to the benefit of two sets of physicians. Those who were already possessors of static machines have had thrust upon them a great aid in making differential diagnosis, localizing an aneurism, stone in the kidney, the presence and site of foreign bodies, fractures, dislocations, etc., as well as its therapeutic uses in a field now so widely recognized. The other set are those who for purpose of employing the X-ray have now at hand, or may have, a means of doing very much valuable therapeutic work that could not be done as well by any other apparatus. So true are these facts that, if for no other reason, one purchasing an X-ray apparatus should select the static machine; but there are other reasons:

So valuable is static electricity in treating a multitude of cases in every hospital and insane asylum in the land, and the grave mistake of placing a coil apparatus that will debar the purchase of a static machine is so apt to occur, that the writer, without prejudice, interest, or bias other than the good of humanity, cannot too strongly urge that the additional first cost is unworthy of consideration.

CHAPTER II.

APPARATUS.

There is probably no department of medicine where success depends more upon the kind of apparatus employed than in that of electro-therapeutics. Since the discovery of the Roentgen ray the static machine has come into great prominence as a therapeutic measure, and the types and capacity of the apparatus show a remarkable want of knowledge on the part of some manufacturers as to the practical requirements of a static machine for X-ray and therapeutic purposes.

Professional inexperience and lack of familiarity with the requirements have made it possible for all sorts of static machines to find places in offices of members of the profession. It is, therefore, the purpose of the writer, in the interest of those who manufacture as well as the physicians who employ the static machine, to indicate what constitutes an effective apparatus without entering into details of construction.

The knowledge of requirement will assist the physician in selecting only such apparatus as will best serve his purposes. The manufacturer will then produce an apparatus to meet the demand. There is no reason why any except machines of great capacity should be constructed at all, because there are no patents affecting the essential working features of the apparatus.

The earliest type of apparatus for producing Franklinic electricity was a crude machine employing a cylinder of amber in which the current was excited by friction. Gradually, vulcanite and glass came into use and the machines were made in various sizes and shapes. The only static apparatus to be found in the laboratory thirty years ago was one provided with a revolving disk having a means of exciting an electrical discharge by friction upon both sides of a revolving plate. The current was collected at one end and conducted to a large

condensing ball, the opposite end of the apparatus being grounded. (See Fig. 1.)

Such machines at best and under most favorable conditions excite but a modest current, and are employed for administer-

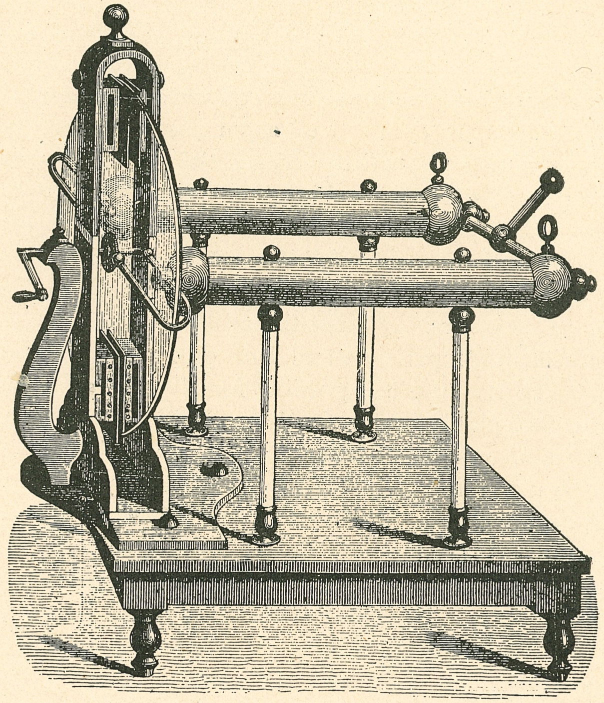


Fig. 1.—Friction Machine.

ing sparks in connection with a Leyden jar. Therapeutically the apparatus was destined to accomplish but little.

The essential requirement for efficient therapeutic work of a modern static machine causes the physician to wonder how any valuable effect could have been derived from the crude devices of the early times.

The first type of influence machine, the Holtz (see Fig. 2), was invented by Holtz, a German, in 1863, and marked a new era in the possibilities of the static machine. In this type of apparatus, it is necessary to employ some means of

exciting the initial charge. In all other respects, the possibilities of the quantity and potential of the current are equal if not superior to the currents produced by the other types of static machines.

The Toepler-Holtz (see Fig. 3) was the next type invented. It is provided with wire brushes, so arranged as to

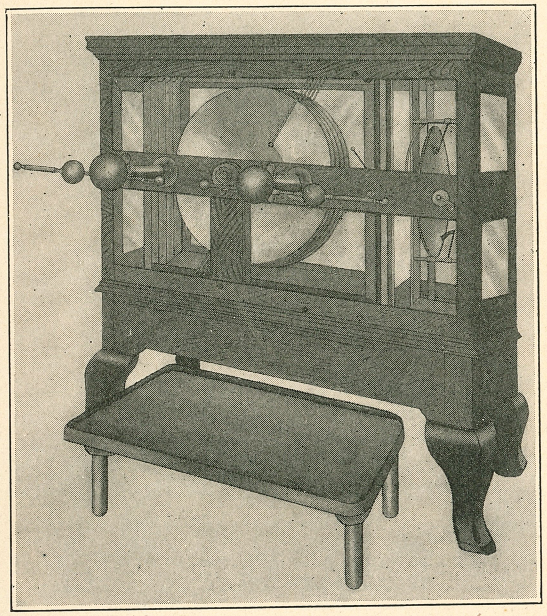


Fig. 2.—A Modern Holtz Machine.

come in contact with metal carriers placed upon the sides of the revolving plates, which renders the apparatus self-exciting. While this type of apparatus possesses such advantage, it is not superior to the Holtz type, and is rarely so constructed as to be capable of producing discharges of equally great potential. The third type of influence machine, the Wimshurst, is also a self-exciting apparatus provided with brushes upon the outer side of pairs of revolving plates, which revolve in opposite directions. This machine combines both the friction and influence element in the excitation of the current. When,

however, not combined in some way with the Holtz principle, it possesses no advantages over either the Holtz or Toepler-Holtz. In fact, large machines of this type have not come into general use, for the reason that there are many disadvantages in the character of the current produced, the spark being

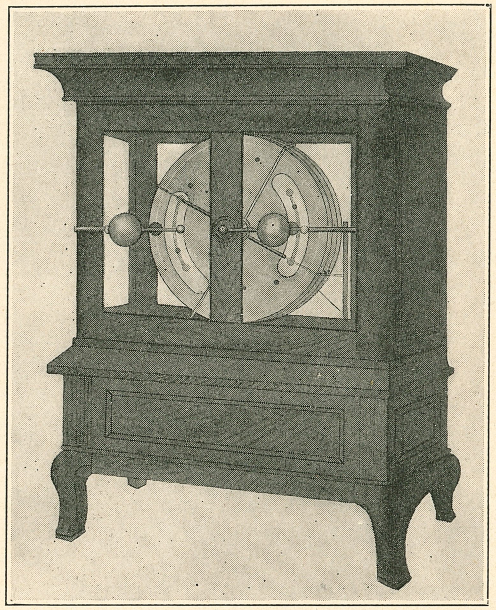


Fig. 3.—A Modern Toepler-Holtz Machine.

a thin, biting discharge not capable of producing the same degree of therapeutic effect.

There has been one machine lately introduced which combines the Holtz and Wimshurst principle, which may meet the demands of the older types. The writer is not familiar with this apparatus, and cannot therefore express an opinion upon its possibilities. The Wimshurst, however, is a valuable accessory of a Holtz machine for the purpose of exciting the initial charge, which, however, in a well-constructed Holtz machine, will seldom be necessary if it is properly cared for, as

the charge will frequently be held for weeks without the necessity of re-exciting.

During recent years the wonderful increase in the production of static machines, in this country, is worthy of note, and the fact that all manufacturers are busy bespeaks the interest taken in the subject by the profession. It is of the utmost importance, therefore, that the machine shall be constructed in a practical and efficient manner. The writer will consider the relative value of apparatus from the standpoint of the required capacity to do the work demanded for X-ray and therapeutic purposes, without entering into the details of physics and type of construction.

The two qualities of all electrical currents are the voltage, or E.M.F., and the amperage, or quantity, which vary with the conditions and character of the source. The static currents are of relatively high voltage, but possessed of a quantity so small that no milliampere meter now manufactured will measure the current of the most powerful machine.

The voltage of a current is relatively measured by the length of the spark-gap produced, and is approximately 35,000 volts for the first inch spark, and some less for each additional inch of the spark-gap. The voltage capacity of a machine depends upon the diameter of the revolving plates and the speed of the machine, but can never be greater than one-half the diameter of the revolving plate, or the distance of the shortest arc or space between opposite polarities of the metal parts. In other words, in a machine of any type the distance between the metal portions of opposite polarities at the spark-gap or within the case will measure the limits of the possibilities of the apparatus, no matter what the speed or diameter of the revolving plates. If, however, a current is excited under conditions of very rapid revolutions, with a machine of a given maximum spark capacity, it will have the frequency relatively increased, but not the voltage, the voltage being measured by the possible spark-gap.

It is a misconception with some who believe that a high rate of speed increases the possibilities of an apparatus, other things being equal, except in the matter of frequency. The

quantity or amperage of current depends upon the number and size of the revolving plates and the condition of the apparatus. Therefore, an apparatus to produce a current of average capacity of amperage and voltage, valuable for therapeutic and X-ray purposes, must be provided with a goodly number, eight or more, of revolving plates, each at least thirty inches in diameter and capable, under favorable conditions, atmospheric and otherwise, of producing a fourteen-inch spark at the spark-gap, without Leyden jars.

Regardless of the claims of manufacturers, the work done must be the test of excellence. In order, however, to have a machine approach the maximum possibilities, there are certain features of construction essential: (1) The insulation at all points where the charge might escape must be as nearly perfect as possible. Vulcanite and glass are the materials employed in the construction of static machines which best serve for purposes of insulation. Wood must never be relied upon to prevent the escape of the static current, and the metallic conductors of the current must be heavily insulated with vulcanite or glass over the shaft, and at all points where they pass to or through the wooden case of the machine. (2) The case should be constructed as nearly air-tight as possible, to prevent the influence of humidity upon the working parts of the machine.

The manufacturer who would convey the idea that any apparatus can be so constructed as to not be susceptible to atmospheric influences impeaches the intelligence of the profession. There are two facts in conformity with the natural law: (1) an influence or friction machine to excite a powerful current requires that the parts of the apparatus be dry, and that within the case the air be relatively free from moisture, and (2) a current when excited, to be delivered to the patient, requires that the atmosphere outside the case also be dry; otherwise, it will be conducted away, and only a small portion be administered to the patient.

The value of the greater amperage of the current produced under conditions of humidity is instanced when administering the wave-current with a static machine of eight or less

revolving plates to one patient, and observing the difference in the length of the spark-gap from a twelve-plate machine under otherwise similar conditions. When, as above, the spark-gap derived from an eight-plate machine will be but one inch, at the same time a twelve-plate machine will administer a spark-gap of three or four inches.

The wisdom of operating a static machine having at least twelve revolving plates in a climate subject to humidity will be apparent from the above facts.

A practical test which is applicable to every type of static machine, and which may serve as a guide to the profession in the decision as to the value of a given apparatus, may be made as follows: (1) Ground the negative side of the machine to a direct ground connection, as a water pipe or gas pipe. (2) Place the shepherd's crook from the positive pole to the platform, the latter being removed three feet from the machine, and not nearer than three feet from any conducting object. (3) The legs of the platform in justice to the machine being tested should be at least nine inches long. Operate the machine at a rate of speed which will give the full output of the apparatus, and separate the balls of the discharging rods to as great a distance as a spark will pass at the spark-gap. This test should be made upon a day when the atmospheric conditions are favorable to all static apparatus—a day when the hygrometer will not indicate more than forty per cent. humidity. The Leyden jars should be detached during the test. A machine in good working order which will not, under these conditions, cause a spark twelve inches long to pass with a frequency of at least sixty per minute is not capable of doing therapeutic service in most difficult cases under varying atmospheric conditions. Another test to be made in connection with a Crookes tube and ball interrupter is given in Chapter III. of Section II.

These tests are practical, and will enable physicians to judge of the respective merits of apparatus. If static machines are not made to meet these standards, attention to the details of the construction, insulation, and other features will enable all manufacturers to meet the requirements, because the prin-

ciples upon which these possibilities depend are in no case protected by patents. Therefore, it is clear that apparatus should be produced to meet the above standard.

The Leyden jars are of relatively little value, except as used with the static-induced current in connection with a properly constructed static machine. The habit of manufacturers to make much display of Leyden jars is misleading to those not familiar with static administrations. Those who have longest made use of static electricity seldom employ them.

The accessory appliances for static administrations are as follows: (1) **The insulated platform** (see beneath the machine, Fig. 2) should be about two feet three inches by three feet six inches, and provided with glass, porcelain, or vulcanite legs (preferably glass) not less than nine inches in length. There are many machines on the market which are provided with platforms too small to use with a suitable operating chair, and few are made with legs longer than six inches. If a machine is capable of exciting a powerful current, it is unfortunate to permit it to escape and thus lessen its efficiency by an oversight so insignificant as the length of the legs of the insulated platform. It is clearly demonstrable that nine or ten inches is at least necessary to prevent such escape.

An operating chair for the purpose of convenience and practicability is a valuable accessory to therapeutic work. Such a chair is shown in Fig. 4. It is provided with a high back, making it possible to hold an electrode against the neck. It is so constructed that the back may be lowered and an extension provided for the feet in order that the patient, if so desired, may lie at full length upon the chair. The seat is twenty inches wide, and arms are provided for the comfort of patients during long administrations.

Stirrups of wood should also be provided, which will enable the operator to place his patient in various positions for making the necessary administrations. While a chair of this particular design is not indispensable, we believe that it will generally be found convenient.

The common electrodes and instruments for general purposes should be **three ball electrodes** for administering sparks,

having diameters of two to two and three-quarter inches, one and one-half inches, and one-half inch respectively. The small ball, Fig. 5, is for the purpose of administering sparks in

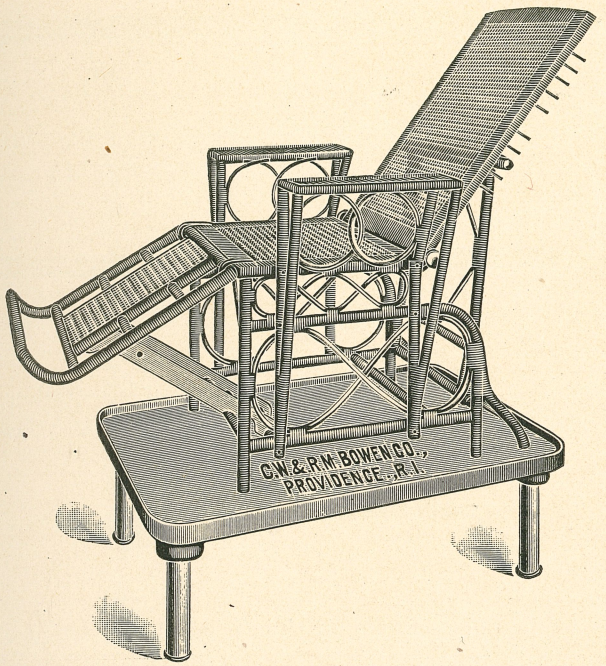


Fig. 4.

the angles and clefts of the body. The middle size, Fig. 6, is convenient for administering sparks to the hands or face. The largest ball, Fig. 7, is for most common use in the administration of sparks and friction sparks, and should be provided with

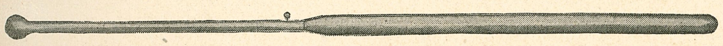


Fig. 5.

a metal portion extending from the brass ball to the vulcanite handle, and will be found convenient if made for application of friction sparks to convex surfaces, curved to adapt to the parts

at the junction with the ball, as shown in the accompanying cut. **One roller,** which is of no therapeutic value, as the friction

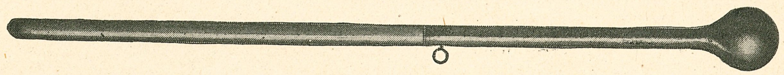


Fig. 6.

sparks are more conveniently administered from the brass ball above described (see Fig. 8); a roller, however, is of great con-

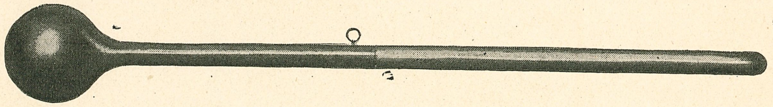


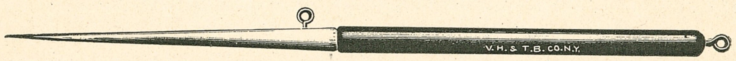
Fig. 7.

venience in smoothing out the soft metal electrodes; **one metal point electrode,** the point of which should be very

Fig. 8.

sharp (needle pointed) for administering the spray (see Fig. 9); **one chain holder** (for holding the chain during admin-

Fig. 9.



istrations of the direct spark, breeze, or brush discharge, or for preventing the cord from coming in contact with the patient

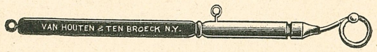


Fig. 10.

when administering the high-frequency discharges with the glass vacuum tubes) (see Fig. 10); **an adjustable stand** hold-

ing a long point electrode (see Fig. 11); **a set of wooden brush-discharge electrodes** (see cut under Brush-Discharge); **a variety of vacuum and Geissler tubes** (see High-Frequency

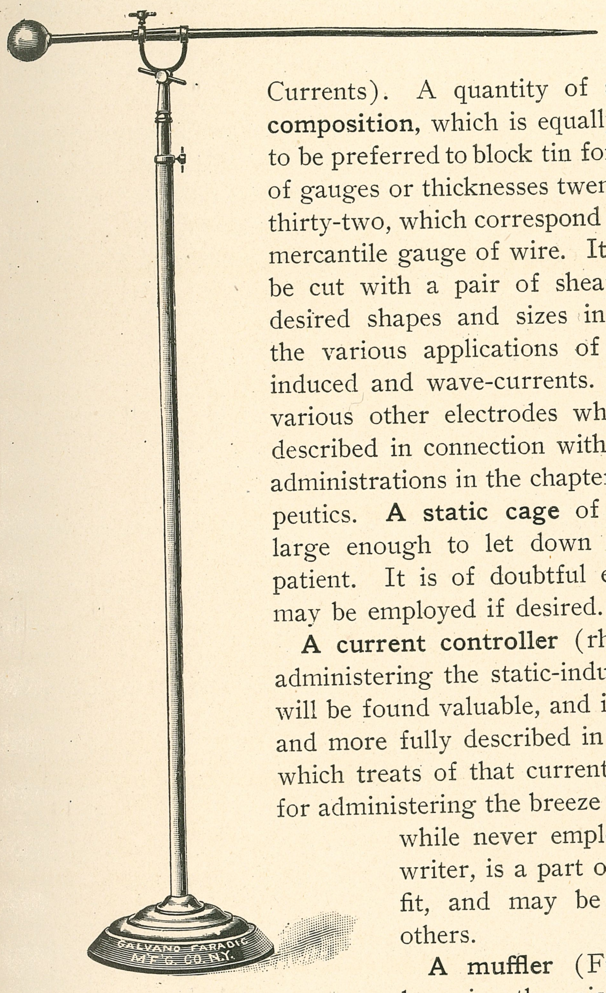


Fig. 11.

Currents). A quantity of **soft metal composition,** which is equally good and to be preferred to block tin for electrodes of gauges or thicknesses twenty-two and thirty-two, which correspond to the B. S. mercantile gauge of wire. It may easily be cut with a pair of shears into the desired shapes and sizes indicated for the various applications of the static-induced and wave-currents. There are various other electrodes which will be described in connection with the special administrations in the chapters on therapeutics. **A static cage** of wire mesh large enough to let down around the patient. It is of doubtful efficacy, but may be employed if desired.

A current controller (rheostat) for administering the static-induced current will be found valuable, and is illustrated and more fully described in the chapter which treats of that current. A crown for administering the breeze to the head, while never employed by the writer, is a part of every outfit, and may be desired by others.

A muffler (Fig. 12) for lessening the noise during the administration of the spark-gap currents will be appreciated by many nervous patients as well as the physician himself. Such mufflers, however, to

allow of the best results when employing the wave-current should be at least ten inches in diameter, and are best when made of several thicknesses of papier mâché, and provided for the convenience of the operator with a window of isinglass through which the length of the spark-gap may be seen.

The appliances for use in skiagraphy will be described in the chapters devoted to that subject.

An electric motor and current controller, a water motor, gas or gasoline engine will be found indispensable if the best results are to be obtained. It is impracticable and impolitic for a physician to endeavor to turn the machine himself, and the presence of a man is often objectionable, and the results

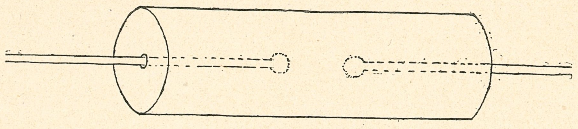


Fig. 12.

never so satisfactory as when some other reliable power is provided.

When employing the alternating current, which always gives a uniform speed, it will be found necessary to make use of some method of controlling the speed, for which purpose there are various mechanical speed controllers on the market.

When employing the direct current, the controller should be provided with at least ten resistance steps for making the changes slight and corresponding contact points for varying the rate of speed. Of all sources of power for static administration, a suitable water motor is to be preferred, because the speed may be controlled readily with the cut-off by slight variation to any desired rate.

The gas and gasoline engines are inconvenient, as they must of necessity be placed in the cellar of the house. If they must be employed, it will be found convenient if they can be connected with a pump and tank, and provision thus be made for raising and storing the water at a suitable height to obtain the necessary force to run a water motor.

A hygrometer will be found of value in determining the condition of the machine from month to month, for under the same relative atmospheric conditions the discharge from a machine is uniform or the machine is not in a normal condition.

CHAPTER III.

CARE OF THE MACHINE AND MANAGEMENT DURING PERIODS OF HUMIDITY.

Location of the Machine.—A damp house, either on account of improper construction, as is the case with many of the older brick houses, or from location with reference to the exclusion of sunlight, will cause no little trouble, and greatly impair the working and condition of a static machine, if the most constant care is not exercised. It is of the first importance, then, that a machine be placed in a properly constructed and well-located house. A room on the sunny side of the house, if convenient, will be of marked advantage in caring for the machine.

It must be borne in mind that, regardless of what manufacturers say, during periods of humidity moisture will get into the case, and, furthermore, if it should not, the air, as it becomes more and more saturated with moisture, will finally conduct away the electricity as rapidly as it is excited, and the patient will get little or none. This is due to conditions not met with in other electric currents, and is therefore little appreciated by those unfamiliar with the use of static electricity. The conditions arising during periods of humidity are: (1) The moisture gradually creeps into the machine and interferes seriously with the excitation of the electric currents. (2) If conditions within the case permit the induction of the currents, the air, no longer acting as a dielectric, conducts away the electricity of very great potential and infinitesimal amperage. (3) The consequence is the patient is not treated nor the Crookes tube excited. The first difficulty may be obviated or remedied in several ways, and deserves attention because the maximum current excited insures the delivery of the largest possible amount to the patient.

To remedy this difficulty to some extent there are various

methods. (1) Some advocate keeping no chemicals within the case for absorption of moisture as it may accumulate, but use means to get rid of it. One method is to fill a large fruit jar with well-mixed, finely cracked ice and salt, in about equal parts, and having wiped the surface dry, quickly place it upon a plate within the case, and promptly close. The moisture within the case rapidly condenses upon the surface of the jar, and in less time than by any other method the moisture is condensed, the air dried, and the machine will charge.

This procedure will be practical only when a machine is new or has been recently renovated, because the constant electrical discharge within the closed case of the machine evolves not only moisture but ozone and nitrous acid, which attacks the metal parts and may form in machines in which $CaCl_2$ is used a sticky coating upon the stationary and revolving plates. To lessen this action as far as possible some chemical should be employed which by chemical affinity will engage the detrimental agents, and thereby defer the necessity of renovation.

(2) Calcium chloride has in the past been regarded as an efficient agent for the purpose of absorbing moisture, but it has failed to engage to any appreciable extent the nitrous acid, which combines with H_2O, and forms a coating of nitric acid upon the glass plates, and this, together with moisture which accumulates, gradually impairs the capacity of the machine. The crude commercial chloride of calcium seems also to contain an excess of chlorine which adds another corrosive to the products of electrical discharge. Some have obtained from chemically pure calcium chloride better results than they had obtained from the crude and report in favor of its use.

(3) After much experimenting with the preceding methods the writer has adopted quicklime, the ordinary calcium oxide of commerce.

The only objectionable feature discovered from the use of this agent is the liability of the dust flying about and coating the glass surfaces of the machine. This, however, is obviated by placing the lime in an open box and covering it on all sides with two thicknesses of good muslin. The box may be constructed with lath sides, the strips being placed one-fourth of

an inch apart, adapted in shape to the machine, and large enough to contain about twenty pounds of lime.

If the lime is changed monthly under average conditions the machine will remain in excellent order. It may, however, be found in the humid season that the lime will become slacked in less time than one month, while during the cold, dry months of winter it may not be necessary to change it oftener than once in two months. The indications for changing the lime will be a disposition, when the machine is of the Holtz type, to lose its charge, or to excite less current under the same conditions. The writer has known his machine, which was used daily during the humid season, not to lose its charge once or fail to excite a current during one month of more or less humid weather in August when the lime was employed. Furthermore, it is noticeable that when lime is used the odor, when the machine is opened, is not nearly so disagreeable as when nothing is used. The presumption, is therefore, that the lime absorbs some of the noxious products of the electrical discharges. On general principles, then, it is wise to keep the lime constantly within the case, and thereby prevent to some extent the corrosion and deterioration of the machine; for, other things being equal, it must be distinctly understood that all static machines do deteriorate, in proportion to the actual time they are operated.

(4) A method of which others speak favorably is to place a vessel half filled with sulphuric acid in the case.

(5) It has been suggested that the air within the machine may be dried by placing a small electric heater in the case. Such a theory is false, because heat does not consume moisture, but on the contrary increases the capacity of the air to hold moisture. The only possible gain by such a method would be that by heating the glass parts some of the water would evaporate from the surfaces. And as against that problematical advantage there are the disadvantages that the humidity within the case will be increased, and the glass plates will be in peril of being cracked. If the object be to dry the plates it is far better, when possible, to open the case and place the machine where the sun can shine upon it.

(6) A provision that precludes the necessity of any of the above measures, except the employment of lime and ventilation for the purpose of removing the injurious gases from the case, is to keep the temperature of the operating room at 60° to 70° F. during periods of humidity, when the machine will always do good work, and the air remain so dry as not to interfere with the administrations to the patient. This is accomplished as in refrigerators employing condensed CO_2. The gas is passed through a series of condensing pipes communicating with a cylinder of liquid CO_2. A device provided with a thermostatic rod may be so adjusted as to automatically maintain any desired temperature. With such a provision the moisture within the room is condensed upon the pipes and the room is cooled. Wherever any plan is introduced that will maintain the above temperature of the operating room, it will be possible to obtain the best results at all times and seasons. There are but few localities where the necessities for such measures will arise except for a few days during the heated season. In the sanitaria and hospitals of the country the need will be most felt when, in the course of time, the real value of static electricity becomes appreciated and its adoption is universal.

The Renovation of the Machine.—Every static machine will require renovation according to the length of time it is used and the care that is taken of it. Indication that such treatment is necessary will be that the usual methods fail to procure good results. When necessary to perform this task, if the manufacturer's representative is conveniently available it is best to call upon him to do the work. If not, do not despair, for common sense and a little patience will succeed in making it work as well as a new one.

The metal parts and glass plates of the machine must first be thoroughly dried. For this purpose there is no better agency than the sun's rays. Remove the top and ends of the case and place it where the sun can shine upon it for several hours. Nothing more may be required. It will be well, however, at this time to cover the revolving plates of the Wimshurst (if the machine be of the Wimshurst-Holtz type) with a coating of the best shellac. The latter procedure will be difficult without taking the machine apart and removing the plates.

This is not difficult, if pains are taken to obtain the necessary instructions from the manufacturer. It is always well for the physician who lives at a distance from the place where the machines are manufactured to avail himself of the opportunity of observing the construction of the apparatus at the factory. When it is not possible to dry the machine in the sun, and it is not convenient to take it apart, a yardstick, about one end of which is wound a piece of chamois, will remove much of the accumulated moisture if the parts are carefully wiped; after which place fresh quicklime within the case. When the machine is renovated the metal parts inside the case should be lacquered. It is well to have a reserve set of these parts that can be put in the machine at such times as renovation is found necessary. A machine thus cleaned is in every respect as good as new. The external metal parts—the prime conductors, discharging rods, and small balls—should be kept well cleansed or polished and free from dust to prevent the escape of electricity from a multitude of small points which accumulate on them.

Carefully note from day to day the condition of the interior of the machine, and adjust the plates or combs whenever friction of the parts is discovered. The chafing of the revolving plates against the stationary ones, if not otherwise discovered, will be indicated by white spots near the circumference of the revolving plates. It may often be necessary to remove the top of the case to locate and correct the trouble. No special mechanical skill is required to make such adjustments. The greatest annoyance when the case is first opened, however, will be occasioned by the irritating contents of the case. If the weather conditions are favorable, it is always best to let the gases escape. At any rate, take care not to inhale the gases, for, though not dangerous, they will induce paroxysms of coughing and discomfort which may last for hours. Whatever the character of the bearings, keep them well oiled. This injunction should not be necessary, but it is often neglected and easily avoidable damage done to the only part of the machine subjected to friction and liable to wear. With proper care, a well-constructed static machine will last a lifetime and work satisfactorily.

CHAPTER IV.

CHARGING THE MACHINE, DETERMINATION OF POLARITY, AND PROVISIONS FOR GROUNDING.

With the Holtz type of static machines it is necessary to provide apparatus for exciting the initial charge. For this purpose a small Wimshurst, which may be either placed in an apartment in the larger case, where it will not receive the excess of corrosive gases, or in a separate case, should be provided.

Charging the machine, which, when the charge has escaped, is a prerequisite to every form of static application, under favorable atmospheric conditions, when the machine is in good order, is but a matter of a moment's time. A machine in good condition, which is used every day, may not discharge for months, if care is taken to leave the discharging rods widely separated. If, however, moisture has gotten into the machine, or during periods of humidity, the task will often tax the skill, patience, and energy of an adept.

(1) Make the necessary connections (which vary with the makes of different manufacturers) to place the Wimshurst in connection with the opposite sides of the Holtz.

(2) Separate the balls of the discharging rods about one-half inch and give the Wimshurst several vigorous turns before starting the Holtz (if the Wimshurst is operated by hand).

(3) Next start the machine, at the same time moving the Wimshurst rapidly, and almost instantly a torrent of sparks will pass and continue when the Wimshurst is at rest. The machine is then charged.

(4) Cut the Wimshurst out of circuit and gradually separate the discharging rods; allowing the machine at the same time to run rapidly until a maximum charge is obtained.

If, for reasons due to the condition of the machine, it is not possible to excite the necessary charge, the fault must be

with the Holtz or Wimshurst or both. If after ten minutes' effort, employing the following maneuvers, the machine does not charge, prepare to put the machine in order, and either replace the wet calcium with fresh, rebake it, put in fresh lime; or, at this time, if the machine is in immediate demand, resort to cracked ice and salt. (See Care of Machine.)

The maneuvers which often succeed under difficult conditions are the following:

(1) When the Wimshurst fails to give the usual one-half inch or longer spark, if revolved several times in the opposite direction and then reversed, the current may be promptly excited. If, when rapidly moved, the Wimshurst will not generate a spark between the balls of the discharging rods at least three-eighths of an inch in length, it will cost a struggle to get the charge. One-half inch will usually succeed.

(2) Having carefully removed with a dry cloth or chamois all dust and moisture from the exposed metal parts of the machine in connection with the circuit, separate the balls of the discharging rods as far as a spark will pass when the Wimshurst is revolving rapidly. While rapidly turning the Wimshurst, start the Holtz slowly, little by little increasing the length of the spark-gap, when after an instant, if sparks continue to pass between the balls, suddenly increase the speed of the Holtz, and the machine will either charge, or the sparks cease passing. Shorten the spark-gap a trifle and repeat the maneuver. If this plan is tried over and over again, turning the Wimshurst very rapidly, starting the machine very slowly and then increasing the speed, success will often reward the effort.

Failing in this, if the humidity is near eighty per cent. and there are no means for cooling the room and thereby condensing the moisture, there will be little use in continuing, for under such conditions most of the current excited will pass through the atmosphere, so that no treatment would prove effective. If, however, the fault is in the condition of the machine, and charging involves much exertion, and the busy hours are at hand, do not let it once stop, nor close the conducting rods within one-half inch of each other until the last patient is treated, and then see that the machine is renovated.

If plenty of fresh lime is kept within the case during the heated season, such necessities will rarely arise except from extreme humidity.

The polarity of the machine may change from side to side if discharged when taking a new charge. It is necessary to have some manner of determining which are the positive and negative poles. The operator familiar with the work readily discerns the difference in the appearance of the discharge from the two poles when the discharging rods are separated just so far that a spark will not pass—the fan-tail discharge from the negative radiating in straight lines from the ball, and the broken tree-like discharge from the positive. While charging, note the spark discharge between the balls. The bright dash will be on the positive side.

It will also be observed that when the balls are a short distance apart the discharges will appear different on the opposite sides, the light end being on the negative and the violet on the positive side. This is the reverse of the preceding observation. It will also be observable that when a wooden stick is placed by the ball of the positive side and moved outward from the convex surface, the discharge will follow the stick, which is not true under similar circumstances with the discharge on the opposite side.

The groundings in connection with static administrations are of greater importance than is supposed by many operators. When administering indirect sparks, breeze, spray, brush-discharge, high-frequency administrations, or the wave-current, it is necessary to ground the side of the machine not connected with the patient or platform if the most pronounced effect is to be derived. The effects are also increased by two distinct groundings having connection with moist earth at points removed from each other. In other words, if the water and gas systems of pipes in modern houses enter the earth at opposite sides of the house, there will be a distinct separation between the groundings. By this plan the influence of the external capacity of the earth intensifies the effect.

A word of caution to the uninitiated in the matter of grounding to the gas pipes whenever connected with the elec-

tric lighting or power system of wiring, is important, for the high-potential current of the static machine whenever it crosses a commercial circuit is certain to melt the fuses and cut out the light or power from the premises, often causing serious inconvenience.

When, therefore, it is not possible to ground to the gas system for the above reason, it will be a simple matter to carry a small wire to the basement, and connect it with an iron rod driven five or six feet into damp earth.

Screw-eyes from which wires extend to the two groundings may be placed at convenient points for these two groundings; one for grounding either pole of the machine, and the other for grounding the chain connected with the operating electrode.

It will be the intention of the writer without further explanation to refer to the two groundings, meaning always the two distinct connections provided for grounding the machine and the operating or stand electrode.

CHAPTER V.

CLASSIFICATION OF STATIC MODALITIES.

The forms of application used in the treatment of diseased conditions have been classified as the convective, disruptive, and conductive discharges.

The convective discharges include static electrification, interrupted or constant, administered with the patient seated upon the insulated platform, which is known also as static bath and static insulation; the breeze and spray as given off from metal electrodes (single or multiple); the brush-discharge, as administered from resistance electrodes usually of wood, and the high-frequency discharges from the glass vacuum tubes.

The disruptive discharges comprise the various sparks, long, short, and friction.

The conductive discharges constitute the currents derived from the static machine. They comprise the static-induced current and the wave-current with its modifications.

These forms of application have been mentioned by many writers as the static currents, a term which is applied to the various modalities, but which, while technically correct, tends to confuse those who are not familiar with the consideration of displacement currents.

The above classification, therefore, is wisely adopted by authorities, and is deserving of general recognition.

CHAPTER VI.

THE DISRUPTIVE METHODS OF APPLICATION.

THE oldest form of static administration is sparks. Abbé Nollet in 1734 was the pioneer. Later Benjamin Franklin, after whom this form of electricity is commonly named, because he first discovered its relation to the lightning of the clouds, also employed the sparks for the treatment of certain diseased conditions. He made use of Leyden jars, which he first charged from a friction machine of his own design. John Wesley (the founder of Methodism), and others, are reported to have performed many cures by their use. Vigoreaux in Charcot's clinic brought the use of Franklinism into great prominence before the medical profession, and deserves the credit of its institution into more general medical use. Morton, a student of Charcot, brought the first influence machines to this country in 1881, and to his efforts and teachings the world is greatly indebted, both for a definite knowledge of a proper administration and correct electro-therapeutics.

The employment of sparks, unpleasant as is the sensation, performs useful services which no other therapeutic measure can accomplish. In the administration of sparks, there is some diversity of opinion as to the effects of polarity. One patient will tell you that the negative spark is most painful, and another that the positive is. In reality there is little difference: both are painful and both are effective. The choice, however, is in favor of the positive spark—the spark of positive insulation—because a longer, cleaner spark is produced from that connection. The negative is more apt to split or divide, and does not seem to produce the same deep perturbatory effect. The spark of positive electrification is therefore preferable in spark administrations. When about to administer sparks, ground the negative pole and connect from the posi-

tive, placing the shepherd's crook in contact with the plate or chain attached to the plate upon the platform. Take care that all metal parts connected with the machine are about one foot removed from the feet of the patient, lest sparks not intended should pass, causing unnecessary discomfort to the patient and producing an unfavorable impression of the operator's neglect or inexperience. Be sure that the platform is removed two and one-half to three feet from the machine; also avoid placing the platform near or beneath a chandelier or other metal conductor. Place the chair upon the platform so that the patient sits directly opposite the prime conductor of the positive pole (the side connected with the platform). There are two reasons for this precaution: (1) Should the patient accidentally touch the ball he will not get a spark, and (2) he will draw off none of the current and thus diminish the effect which, under certain conditions, may be required.

The patient being seated upon the platform, and the operating chain having been connected at one end with the ground (the one not connected with the negative pole of the machine) and the other with the screw-eye in the side of the handle of the ball electrode to be used, see that the prime conductors are widely separated, start the machine at a rate of speed commensurate with the length of the spark to be administered, which will vary with weather conditions.

When treating a timid patient, at the instant immediately preceding the application of the first spark, or following intervals of rest during treatment, place the ball, or one foot, against the platform to draw off the surplus of charge, or the first spark will be unnecessarily severe.

There are several common methods of regulating the length of the sparks to be administered: (1) by varying the speed of the revolving plates; (2) by regulating the proximity of the plate or chain upon the platform with the feet of the patient; (3) by placing the discharging rods at varying distances, according to the length of spark to be administered; (4) by the operator drawing off a part of the current by placing the foot upon the platform, standing off when long sparks are desired, and drawing near or placing one foot upon the platform

when the shorter sparks are preferred. The latter plan is valuable when giving a patient a general treatment by sparks, because it is desirable to apply long sparks to some parts of the body and shorter ones to other regions. (5) When powerful effects are sought, the patient may take the chain or shepherd's crook in his hands (a very disagreeable method for the patient, because of the painful contraction of the muscles of the hands), or stand, with the shoes removed, upon the metal plate. This plan will also be valuable during periods of humidity, when the output of electricity to the patient is small.

When administering sparks, use a wrist movement instead of arm movement, which is awkward and tiresome. Judging at what distance from the patient a spark will be discharged, move the ball to that point and immediately withdraw before a second spark escapes. Repeated sparks to the same point are exceedingly disagreeable. With a little patience, employing the wrist movement, the knack of administration is soon acquired. A swinging motion, allowing single sparks to escape, as the ball is passed to and fro, is another method useful in making application to convex surfaces. When treating anæsthetic areas, or patients who are tolerant from familiarity or hardihood, much time may be saved by rapidly passing the ball electrode parallel with the surface of the body at such a distance that rows of sparks will be discharged.

The application of sparks in hollows or angles is often difficult of performance, as in treating the throat or perineum. The small ball electrode meets the difficulty in treating the throat.

The size of the ball electrode determines the fatness or width of the spark. Sparks applied over bony prominences do no good and are exceedingly painful. Do not apply sparks to the breasts of the female, to the external genitals of the male, nor to the nails of the fingers and toes, for these parts are exceedingly sensitive. When administering sparks or the convective discharges over wet clothing and fabrics which are conductors, of which cotton is an example, the effect may be abortive. Over such garments place some good non-conducting material

—a piece of woolen cloth or a newspaper—and the results will be satisfactory.

Sparks may be distinguished as: I., indirect; II., direct; III., friction, and IV., Leyden-jar. Their peculiarities, indications, and modes of application may be described as follows:

I. The indirect spark is the form indicated in most instances where sparks should be administered. The modes of making the connections are as follows: (1) By means of a chain connect the negative pole with a direct metallic ground connection. (2) Place the insulated platform two and one-half to three feet from the machine. (3) Connect the other side of the machine with the platform, using the shepherd's crook, rod, or chain—whichever is provided for the purpose. (4) Widely separate the discharging rods. (5) Connect the operating chain, having the ball electrode attached to another good ground connection. (6) The patient having seated himself upon the platform, start the machine.

II. The direct method is only employed during periods of humidity, when it is often difficult to use the indirect spark. This spark is very painful and can rarely be administered singly. During the administration, the operating chain must be held by the chain holder in the left hand of the operator in such a manner that it does not come in contact with himself or the patient, while the sparks are administered with the ball electrode in the right hand. The mode of making the connections is as follows: (1) Place the platform and connect it with the positive pole of the machine by crook, etc., as in the preceding method. (2) Separate the discharging rods widely apart. (3) Connect a short operating chain, having the ball electrode attached to one end, to the negative side of the machine, and place the spiral of the chain holder at about the center of the chain. The patient being seated, start the machine.

III. The friction spark is administered by rapidly passing a metal electrode over the clothing, all connections being made identically as when administering the indirect spark. During periods of humidity, however, the direct method may be employed. The thickness of the material intervening between

the surface of the body and the electrode determines the length of the spark. The roller electrode was originally intended for use in this form of administration, but is not nearly so good nor convenient as the large ball electrode provided with a handle, having a long metal portion above the insertion of the insulated part. Applying the ball and the metal portion of the handle in making the applications, the electrode can be moved rapidly and efficiently over any portion of the surface of the body. If making a general application of friction sparks, pass the ball and metal portion of the handle very rapidly over the body by long strokes, and when treating small areas interrupt the application at short intervals, and the patient will submit to the treatment the case demands. This form of administration relieves pain, is highly stimulating to the peripheral circulation, acts as a counter-irritant, and promotes secretion and excretion.

IV. The Leyden-jar sparks are too severe for administration except in cases calling for profound mental effect of discipline or suggestion. They would be administered by the same arrangement as the direct sparks; adding two Leyden jars having their outer coats connected by a device provided for the purpose or a metal rod.

CHAPTER VII.

THE CONVECTIVE MODES OF ADMINISTRATION.

THE convective discharges are static-electrification, breeze, spray, brush-discharge, and the high-frequency discharges from the glass vacuum tubes.

Static electrification, also known as the static bath and static insulation, usually administered in connection with a breeze or spray by placing the stand with point electrode near some portion of the body of the patient, is the simplest and to the patient the least objectionable modality.

Undoubtedly much good can be derived from this form of administration. For, though the electrification in the uninterrupted form of administration is associated with a minimum of oscillatory or vibratory effect, there is abundant evidence that metabolism is increased and some conditions of nervous patients are greatly improved by its employment. If the breeze or spray is to be used in connection with the treatment, place the stand electrode with the point directed to the part of the patient where its use is indicated. Start the machine at a rate of speed consistent with the demands of the case and adjust the stand electrode according to the effect desired. The connections for this method are as follows: (1) Connect the patient with the positive or negative side of the machine (it is observed that the beneficial effect is more marked in some patients from positive insulation and in others from negative, which can only be discovered by trying them alternately). (2) Widely separate the balls of the discharging rod. (3) Ground the side of the machine not connected with the patient.

Interrupted electrification, which has been termed by one writer, who also makes the connections in an indirect method,

"potential alternation," is in effect more active and beneficial than the preceding method because the interruptions at the spark-gap produce a pronounced oscillatory action upon the tissues of the patient.

While this form of application has marked therapeutic advantages over the uninterrupted method, it is *not nearly* so effective as the wave-current and as the noise of the spark-gap is the only feature of the wave-current which would lead to the substitution of either form of electrification it would rarely be employed. If, however, it should be used, the only difference in making the connection would be the placing of the balls of the discharging rods at a distance which would permit sparks to pass during the treatment.

The breeze or souffle is a mild form of application and is employed as an accessory to static electrification, constant or interrupted, or the wave-current. The stand electrode is called into requisition and may or may not be connected, according to indications, by the operating chain to one ground connection. The point of the electrode—either bare or having the crown, or a tassel, attached—is placed over the head of the patient, or the point alone near any other part to which it is desired to draw the bulk of the discharge. Another method is to connect the brush electrode with the operating chain, taking care that it is kept at the proper distance while moving it over and around the patient. Though not of special value therapeutically, this maneuver often serves a good purpose when introducing a timid patient to static methods.

Another mode of administering the breeze is by employing the static cage, which may be suspended around the patient and provided with a direct connection to the ground, the patient at the same time being seated or standing upon the metal plate. This form of treatment has also been administered combined with interrupted electrification, the spark-gap discharging at any desired length. In this event the patient must stand without shoes upon the plate, or the passage of sparks through the heels and soles will be intolerable. The objections to this method are (1) the suspense of the patient lest he get a spark; (2) some portions of the person of the patient will be nearer

the metal of the cage than others, and from such surfaces the current will nearly all escape, and the treatment intended to be general will become local without reference to the lesion; (3) the apparatus is cumbersome and expensive, and at the same time not so effective in its constitutional effects as the wave-current (see Wave-Current Constitutional Treatment), which it simulates.

The spray is a warm or hot breeze, differing from the breeze in arrangement only in the nearer proximity of the electrode to the person of the patient. To produce the strongest effect

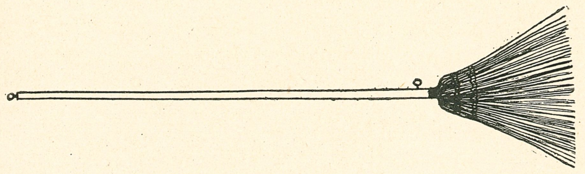


Fig. 13.

of the spray, there must be some non-conducting material, except over the hair, between the surface of the body and the electrode. A thick woolen or silk garment produces the strongest effect. It will be convenient to have a square yard of suitable material (silk or woolen) for use when treating the hands or face, or to throw over damp clothes or fabrics not adapted to the spray or spark. For local use, the spray may be directed to the region affected, employing the point electrode or an electrode having many points, and allowed to pass for five or ten minutes, when it will have rubefacient and anodyne effects. For general treatment, employ the brush electrode in the hands of the operator; passing it at the proper distance about the body of the patient, taking care not to discharge accidental sparks. Administered in this manner, it acts as a mild peripheral stimulant and is not disagreeable to the patient, producing a favorable impression. Unless persisted in for a long time, however, it is not nearly so effective as the friction sparks, which may be applied rapidly and effectively.

The brush-discharge, as the term is employed in electro-

therapeutics, is an electrical discharge taking place between a body insulated and connected with a static machine and an electrode of resisting material, as of wood, and from the peculiar interrupted quality of the discharge might be termed disrupto-convective.

The term brush-discharge is an unfortunate one; because in electro-physics it is applied to an electrical discharge from one terminal of a high-potential apparatus, without regard to the substance of the conductor between the terminal and the course of the current, while the term as used in electro-therapeutics applies to a discharge which passes some distance through a substance of very high resistance that may or may not have a metallic terminal from which the discharge is emitted.

The only source of electrical energy employed in therapeutics capable of passing a current without disagreeable consequences through such resistance is a static machine. The disparity of amperage and voltage is such with currents from other apparatus that their employment is either impossible or impracticable. The intensity, volume, and effect of the discharges vary with the speed and the capacity of the machine, the length, diameter, and character of the resistance electrode, the atmospheric conditions, the character of the material between the electrode and the patient, the nature of the grounding, and the insulation.

(1) The most effective discharges are obtained from powerful static machines, the volume of the discharge being greater from the machines having the larger number of revolving plates, other things being equal.

(2) The material of which the electrode is made is of great importance, in order that it may deliver a discharge that is fine or interrupted as desired and without a disruptive quality, as sparks. Wood is the best material, either the white portion next to the bark of the indigenous soft maple or some other wood of even texture, as whitewood or holly. The red or central portion of the maple is not nearly so good, as the texture is porous and dries rapidly, which makes it a too poor conductor. The electrodes may be frequently dampened

PLATE II.—Method of Administering the Brush-Discharge. Machine Running at a Rapid Rate, Balls of the Discharging Rods Widely Separated, Patient Insulated, and the Wooden Electrode Grounded and Held at a Distance and Proper Angle for Administration.

over the surface with water or better still replaced by new ones, for, as they become dry, the discharge becomes less vigorous.

(3) The opposite side of the machine to which the patient is connected should be grounded to the water pipe, and the end of the electrode held by the operator should be connected by a distinct ground, as the gas pipe, if the strongest effect is desired.

(4) The insulation of the patient should be as nearly perfect as possible. Machines having the capacity of those above described should be provided with insulated platforms having glass or vulcanite legs, at least nine inches long.

(5) The poles of the machine should be widely separated before the patient is connected or the machine started, because it is desirable that the patient should hold the shepherd's crook, when if a spark should pass because the poles are too near, the shock to the patient from such an accident might be discouraging. For application of the brush-discharge special electrodes may be employed.

(6) It has been demonstrated that the brush-discharge from the positive pole is distinctly irritating, and when administered in a dark room, discharges of a green color will be seen mingled with the violet. It is therefore, the rule in the treatment of all inflammatory and painful conditions to connect the patient to the negative pole of the machine when administering this modality.

During prolonged administrations the electrodes, when properly conducting a current, as during the summer or when they have become thoroughly heated, will become disagreeably hot. Under these circumstances the discharge is very rich and effective. It will also be found that during the winter, when the temperature of houses ranges below 70° F. the discharges become feebler, though the output of the machine is greater. The temperature then cools the electrodes and renders them poor conductors. At the same time the air is dried and becomes a more perfect dielectric.

Heating the electrodes during cold weather increases the effect of the discharge at first, but soon causes them to become so dry as to be ineffective. It is then best to replace the longer

part of the electrode with a new stick, or keep the surface thoroughly moistened with a wet cloth or sponge during an administration. The effect upon the wet surface or over wet clothing is *nil*. Cotton or linen, when an outer garment, materially impairs the action, whereas strong effects will be pro-

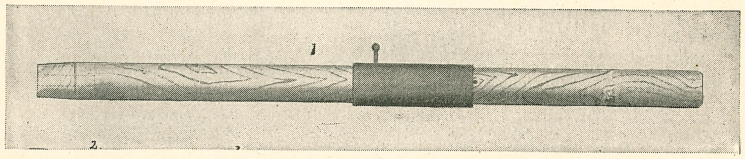


Fig. 14.

duced by placing one or more thicknesses of silk or woolen cloth over the surface to be treated.

Care should be taken that not too many thicknesses of wool or silk intervene, for, if there are too many, they are apt to ignite. Celluloid hairpins for the same reason should be removed.

A hot and humid day in summer, if the machine can be made to excite a current, is the time when the brush-discharge is most potent, other things being equal.

For application of the brush-discharge to the surface of the body the wooden ball electrode of maple, or other wood

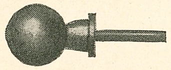


Fig. 15.

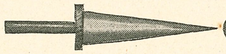


Fig. 16.

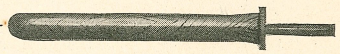


Fig. 17.

of even texture, meets all requirements, except when it is necessary to make the application in a cleft or depression, as between the fingers or nates, in which cases a pointed electrode will be required. A set of terminals has been devised which may be used from the extremity of a handle at least twenty inches long, of a proper material. This handle should be three-fourths of an inch in diameter, provided with a sliding tube having an eye for the attachment of the grounding chain (Fig. 14), which may be moved to and from the extremity, increasing or decreasing the resistance as the case or conditions demand.

The wooden terminals are of value. The wooden ball terminal (Fig. 15) will be most commonly used with this modality. The wooden point (Fig. 16) will be found convenient when making applications of the discharge in the angles and clefts of the body. Another wooden terminal (Fig. 17) designed for placing the test tube over the wood is included. This terminal is of the least value because of the liability of the tubes to puncture when using a strong discharge. It may, however, be found convenient under some circumstances and is considered by some physicians to be a valuable addition to the set. The small terminals (Fig. 18) each have certain ad-

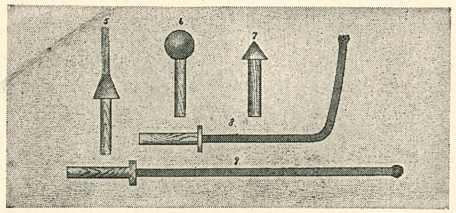


Fig. 18.

vantages. The discharge may be administered more conveniently and localized more accurately by their employment. The one terminating in a few fine wires distributes a soft fine spray which may be applied to some organs, as the eye. The metal ball will give a more concentrated discharge than the wooden ball. The brass point will also be found to have advantages over the long wooden point in certain cases. The two insulated tips are designed for applications within the various cavities of the body. These may be used or a glass tube having a funnel-shaped opening at one end, and made to slip over the handle at the other. By this means it is possible to localize a discharge in a narrow canal without permitting it to escape to the sides, thereby making the application to any desired spot. The value of these insulated terminals will be appreciated by all who are familiar with the value of the modality in the treatment of ulcerated and infected conditions.

High-frequency discharges have been so termed by the French in connection with the current of d'Arsonval. Re-

cently, the employment of glass electrodes in connection with the static machine and various X-ray coils has attracted considerable attention. The characteristics of the discharge depend upon the vacuum tube and vary in color with the high and low tubes. These tubes are made in many shapes designed for special treatment. The Geissler tube, which has the wire connection from the exterior to the vacuum, possesses no particular advantage over tubes having no conducting communication from the exterior. It is a singular property of the high-potential currents that they pass apparently through the glass and are discernible in the interior of the tube. The polarity of the electricity within the tube is demonstrated to be the same as that of the side of the machine to which it is connected. This is shown from the fact that when a tube of high vacuum is connected to the negative side, the cathode ray producing the usual green fluorescence appears opposite an object with which the tube is placed in contact, the object becoming the anti-cathode. The induced discharges which appear on the outer side of the tube when it is brought in contact with the patient or any other conducting media are therefore of the opposite polarity.

The tubes employed are of low or high vacuum, and may be either constructed on the Geissler pattern, having a metallic connection from without, or without wire connection to the interior. This, however, is not of practical advantage in most cases.

An adjustable insulated handle, Fig. 20, of solid glass or vulcanite is a convenience permitting the operator to handle the electrode during an administration without lessening the discharge from the current, which would otherwise pass off through his person.

When a static machine is employed to produce the discharges the positive pole should be grounded and the electrode connected with the holder either placed in some cavity of the patient, or held by the operator and connected with the negative pole. The spark-gap should then be closed to about one-half inch and the machine started, after which the spark-gap is regulated to the condition of the patient.

Plate III.—Administration of the High-Frequency Current with the Glass Electrode to the Fauces. The Electrode Connected by a Cord to the Negative Side of the Machine, Positive Side Grounded, and a Short Spark Discharging at the Spark-Gap.

If a coil is used for exciting the tube, a connection may be made from the negative terminal of the coil, connection being made with the patient as before. The current controller connected with the coil, if no step-up transformer is used, should be provided with many contact points with resistance changes slight or the increase may be unpleasant to the patient. The current, when using a coil, may also be regulated by making use of a Geissler tube three or four feet long, one end of which is attached by one end of the coil, and provided with a ring to which the operating electrode may be attached. The ring can be moved to and fro from the terminal to regulate the discharges, which will then be of secondary induction. In that case, the large tube should be attached to the positive side of the coil.

The high-frequency discharges from the two sorts of apparatus differ somewhat in the chemical, heat, and vibratory effects. The chemical effects are most marked with the coil current because of the greater amperage; and the vibratory effect and muscular contraction, invaluable in the treatment of inflammatory conditions, is characteristic of the static machine and absent in the coil current, or when a coil is used in connection with a static machine.

The technique of employing the Geissler or vacuum tubes is not difficult either with the static machine or coil. With the former it is not necessary to insulate the patient, as with other static modalities.

It has been demonstrated by both foreign and American observers that the larger amount of chemical rays are emitted when vacuum tubes are connected to the negative side of the sources of electrical energy. Therefore make negative connection with the electrode.

The discharging spark-gap is essential to the high-frequency discharges from the static machine, for without it there is no appreciable interruption—no frequency.

To administer this modality, have the patient upon the table or seated in the chair; connect the cord from the glass electrode to the negative side of the machine, and if an application is to be made within the rectum or vagina, place the electrode

in position, or, if the operator is to apply it to the skin or some mucous surface, it should be held in readiness by the glass or hard rubber handle and the machine started. The spark-gap between the balls of the discharging rods should not at first be more than one-half inch. It may then be regulated to the condition to be treated. One to two inches will be required in most cases for treatment of the vagina and rectum, and one-

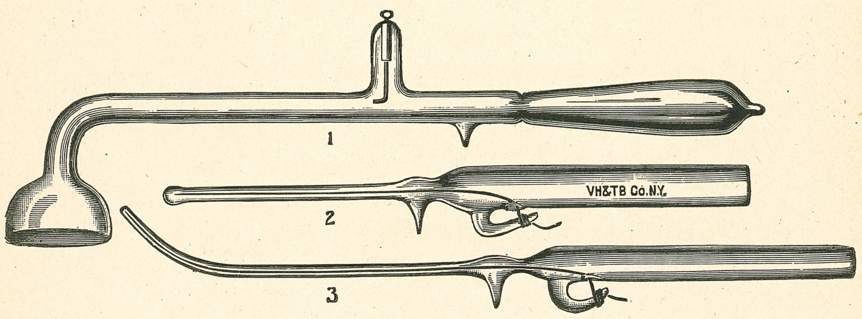


Fig. 19.

half to one inch in the fauces and on the surface of the body.

When using a coil, either in association with a resonator or other apparatus or not, connect with the negative side of the apparatus or, if the alternating current is used, with either side. Having the patient in readiness upon the table or chair, place the electrodes as in the static administration. Then turn on the current gradually, starting from zero. It will be noticed that with currents of larger amperage the violet discharges are more numerous, that the sense of warmth is more pronounced, and the application to the surface, either through the clothing or when held at a sparking distance from the body, more painful than the static.

There is undoubted advantage in some cases in the treatment of which a stronger chemical discharge is beneficial from the greater amperage of the coil. On the other hand, the positive vibratory effect and induction of muscular contraction of the static high frequency, which is easily appreciated by holding an electrode in the hands, has its advantages in overcoming local stasis and congestion.

Vacuum electrodes of various types and forms are employed for making applications of high frequency, all of which are adapted to both the coil and static currents.

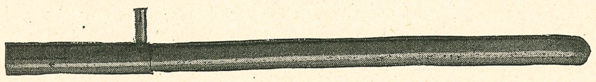


Fig. 20.—Handle.

The Geissler tubes, which were first used in connection with high-frequency apparatus, are constructed, as stated, with wires running from without either to a point within the vacuum portion of the tube or extending along the whole length, hav-

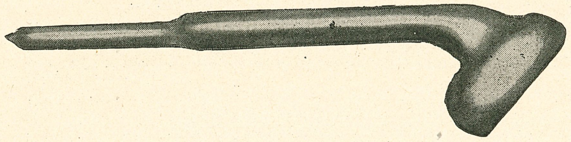


Fig. 21.—Surface.

ing glass insulation for the purpose of delivering the main force of the discharge at the extremity of the tube as shown in Fig. 19.

These tubes possess no special advantage, and, like the glass test tube used in connection with the brush-discharge, are more

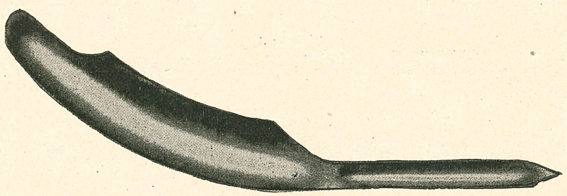


Fig. 22.—Vaginal.

apt to puncture during administrations. More recently, the vacuum tubes have come into general favor, and are practical and not so apt to puncture.

The writer has designed numerous shapes in glass electrodes

which will be found convenient for special applications, which, are used with a handle (Fig. 20), of insulating material of vulcanite or glass adapted for holding the various vacuum tubes.

Fig. 21 represents an electrode for making applications to the surface of the body over the clothing or next to the skin.

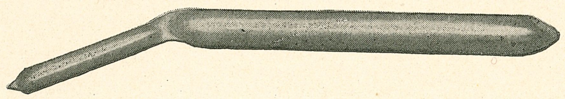


Fig. 23.—Rectal.

The same form of electrode may be provided with a metallic button, which is connected by a wire to a grounding, making it possible with a tube of suitable vacuum to make direct ap-

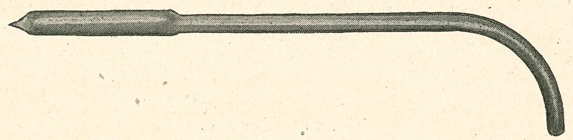


Fig. 24.—Urethral.

plication to the surface of a low-vacuum X-ray, which may be utilized in the treatment of acne and other conditions.

Fig. 22 represents the vaginal electrode constructed with a cup depression at the extremity for receiving the cervix. Fig. 23 represents a rectal tube provided with a conical tip for use

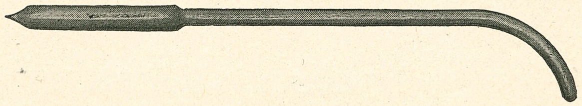


Fig. 25.—Throat.

in treating fissure in ano, rectal ulcers, hemorrhoids, and other rectal conditions. Fig. 24 is of thick glass, and designed for use in the urethra. Fig. 25, provided with a piece of rubber for insulating over the teeth, is for use in the pharynx and larynx. Fig. 26 represents a flattened tube for treatment of the nares.

Another feature of construction of special advantage in vacuum tubes is a plan for insulating certain portions of the tube with an outer tubing of glass having openings to admit the

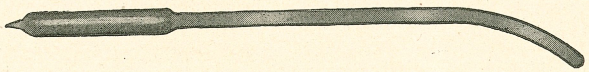


Fig. 26.—Nasal.

air. Such tubes, under conditions of weak currents as are excited by small machines and during periods of humidity, permit a stronger effect over a small region without the pos-

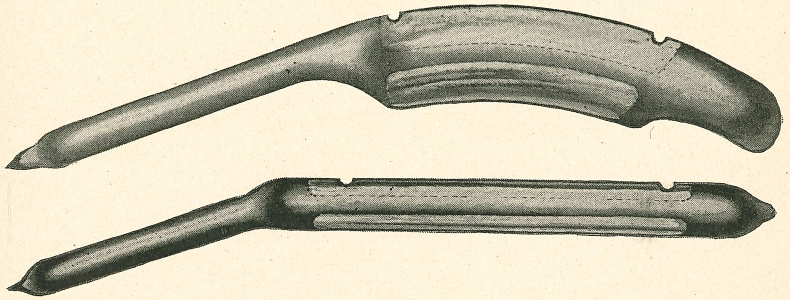


Fig. 27.—Insulated, Vaginal and Rectal.

sibility of the discharge being emitted from the whole length of the tube, and are also of special advantage in aural and throat work.

Fig. 27 represents vaginal and rectal electrodes of this type. Fig. 28 represents an aural electrode especially adapted for

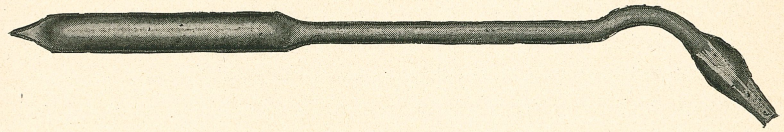


Fig. 28.—Aural.

making applications to the membrani tympani, or to the cavity of the middle ear for treatment of congested conditions, ulcers, or suppurating processes. Fig. 29 represents an insulated

electrode having a flattened portion for making applications to the posterior nares behind the velum.

Therapeutically, the brush-discharge and high-frequency discharges are indicated in the same class of conditions. Wherever congestion and stasis are present, with or without the presence of germ life, these modalities are invaluable. Enough cases of lupus have been reported cured by both modalities to establish their value in superficial tubercular conditions.

The ozone so richly evolved at the seat of application oxidizes organic life, acting as a powerful antiseptic.

The brush-discharge is especially adapted to the treatment of skin diseases. Lupus, eczema, herpes, acne, scabies, and allied conditions are wonderfully relieved and cured by its action.

The high-frequency discharges have accomplished such remarkable results in the treatment of ulcer of the rectum, fissure of the anus, hemorrhoids, tonsilitis, and catarrhal conditions as to assure the modality wide recognition when it becomes better known. The application of the brush-discharge within the cavities by means of special electrodes, assures it new fields

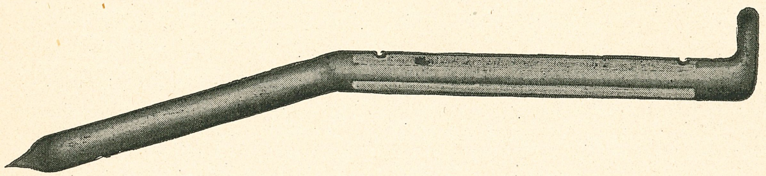


Fig. 29.—Post-nasal, Insulated.

of usefulness. In this manner it has already been employed in the treatment of otitis media, fissures, ulcers, and fistulæ.

The application of the brush-discharge to the early stage of acute inflammatory conditions, rheumatism, sprains, and abscesses, as well as the swelling associated with fractured bones, meets with surprising results.

The static brush-discharge and the high-frequency discharges from both coils and static machines possess the qualities characteristic of all electrical discharges. Decomposition of the atmosphere takes place and, with other products, nitrous acid and ozone are evolved. The green-violet and ultra-violet characters of the discharges, which vary with the degree of vacuum of the tubes, possess qualities also of undoubted therapeutic value.

The physiological actions of the discharges, while similar in many respects, differ essentially in others. The brush-discharge, like other static modalities, lessens local hyperæmia and congestion by inducing contraction of the subcutaneous arterioles, and thereby relieves pain, and diminishes swelling to a marked degree. The metabolic processes of the end organs are stimulated to greater activity and a healthy restorative action is induced. When applied for a long period, the effect is first rubefacient and later vesicant, producing painful blisters. From the nature of the electrical discharge the ozone and nitrous acid evolved from the close proximity to the tissue are distinctly antiseptic. In addition to these local effects, there is a marked tonic effect from its employment when a course of treatment is pursued for a prolonged period and the patient, for any reason, has been below the normal standard.

With the high-frequency discharge from the vacuum tube the local effects are much the same, but possess certain advantages which determine its election for use in the several conditions. For example, when treating cavities of the body, such as the rectum and vagina, it is possible to place the electrode in the cavity, leaving the patient for the indicated period of administration under the same conditions. To apply the brush-discharge would necessitate the use of a speculum and an electrode insulated to the terminal extremity from which the application was discharged, and at the same time require the constant attendance of the operator during the period of administration. In addition, the application, if the surface requiring treatment was extensive, would be prolonged.

CHAPTER VIII.

CONDUCTIVE DISCHARGES.

STRICTLY speaking, all static discharges are currents, passing to and fro through the dielectric, or other media, as the chain or shepherd's crook, which may connect a patient or the platform with the machine or the air of the room. Such passages may be either insensible or associated with disruptive or convective discharges, but are not technically classified as currents, as are conductive discharges.

The spark-gap, as it occurs between the balls of the discharging rods, or in any other part of the circuit, is the distinctive feature of the conductive discharges. From the standpoint of the electro-therapeutist, it was first defined by Morton,* when discussing the static-induced current, in which he referred to it as necessary in the following terms: "A regulated interruption in the otherwise inoperative circuit of a Holtz machine would produce in another part of the circuit a current adapted to electro-therapeutic practice."

In other words, the discharging spark-gap is essential to the production of physiological effect upon a patient placed in the circuit or upon the insulated platform. This is easily demonstrated by placing the two hands upon the opposite prime conductors of a static machine, previously charged, and then starting it at a rapid rate of speed. The passage of the electricity will be absolutely inoperative and inappreciable.

Two spark-gap currents having various modifications have been published and are now generally used and understood by well-informed electro-therapeutists throughout the world. Both bear the name of Morton, who introduced them to the profession—the *static-induced current* in 1881, and the *wave-current* in 1899. Physicists may criticise the nomenclature, but the names are distinctive and for all practical purposes

* Medical Record of March 26, 1881.

equally as good as the terms "*constant*" and "*interrupted*" used in regard to the older currents of Galvani and Faraday.

The static-induced current, first published in the Medical Record of March 26, 1881, and later, more fully and explicitly, in the Medical Record of January 24, 1891, antedated even at the later date all therapeutic consideration of currents of great frequency and high potential. For ten years

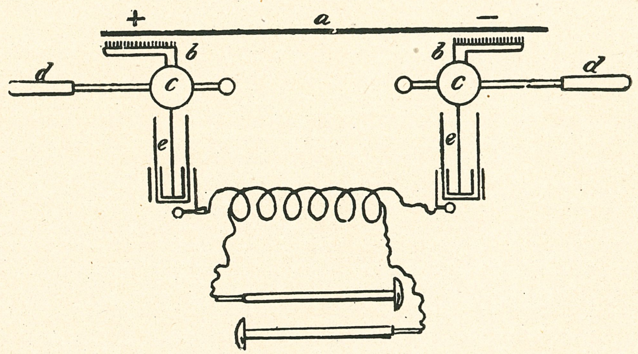


Fig. 30.—*a*, Revolving Plate; *b*, Collectors; *c*, Prime Conductors; *d*, Discharging Rods; *e*, Leyden Jars.

it had been almost unrecognized except by advanced workers and, during that period, was the only published current possessed of such qualities.

The current was known abroad as "the current of Morton." Later the current of d'Arsonval (Fig. 30) was introduced and the consideration of the currents of "high frequency and high potential" came rapidly to be a new element in electro-therapeutics. The apparatus of d'Arsonval was the result of an effort to produce, by transformers and condensers, a current similar to the static-induced current—a current safe of administration, of high frequency and high potential.

The static-induced current is represented in the accompanying drawing (Fig. 31).

To operate this current, (1) place the two Leyden jars to be used in position, connecting the inner coating of the jars with the corresponding sides of the machine, (2) connect the rheophores with electrodes attached to binding-posts provided

on all static machines, (3) close the spark-gap of the machine, (4) place the patient (not necessarily insulated) in position and apply whatever electrodes are to be used in the treatment of the case, (5) start the machine at a slow rate of speed and gradually open the spark-gap until sufficient current strength is indicated by the effects upon the patient. If no controller is employed in the circuit, use very small Leyden jars, as the administration will otherwise be too severe. It is necessary to use some method of changing the character of the current if Leyden jars of large size, such as are attached to most types

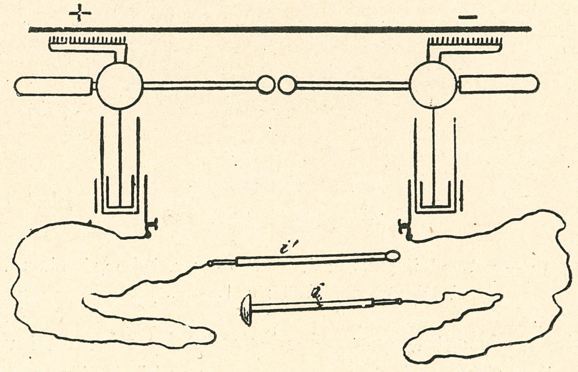


Fig. 31.

of machines, are employed for this purpose. Dr. Margaret A. Cleaves has devised a water rheostat, Fig. 32, which is a modification of the Craido. By this means, it is possible to employ the large-size jars and the longer spark-gap, when the current may be of greater amplitude and less painful than when employed directly to the patient without such device in the circuit.

The static-induced current may be employed in all conditions to which the high-tension coil is adapted, and is a useful adjunct in the treatment of many cases of constipation and painful neurosis when it is necessary to obtain a very powerful local effect. The electrodes employed are preferably of metal, as those covered with felt, sponge, or other similar material

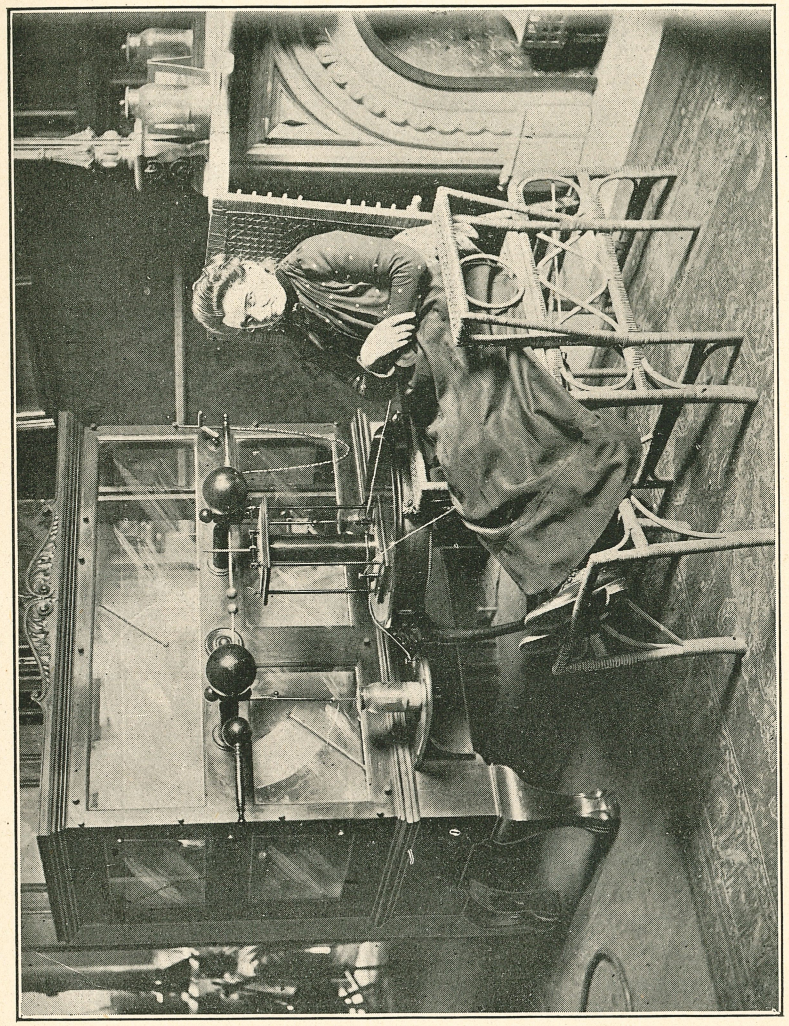


PLATE IV.—Administration of the Static-induced Current, Employing the Cleaves Controller. The Electrodes Connected One on the Abdomen and the Other Rectal Electrode as in the Treatment of Constipation. The Controller is not Generally Essential in the Treatment of Constipation.

must be kept very wet, or disagreeable sparking will make the application intolerable. It is applicable in all cases to which the wave-current is applied for local treatment, but does not combine with it the constitutional effects of the wave-current. It is especially valuable, however, when there are indications for local treatment of two separate regions to which it would otherwise be necessary to make two prolonged administrations of the wave-current. It will repay those who employ this current to any extent to procure the Cleaves rheostat, because the

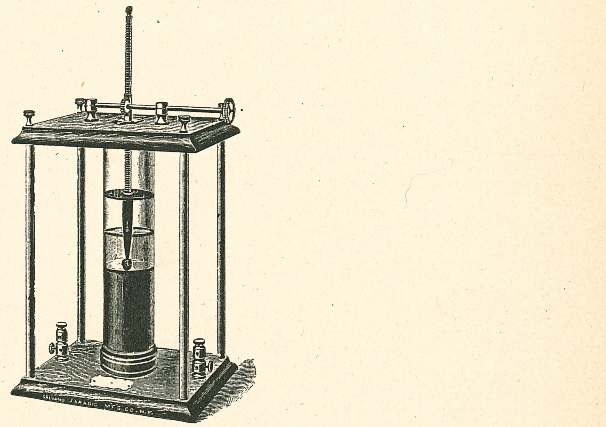


Fig. 32.

administration is much less painful and generally more effective when it is employed. Another use for this current is in connection with step-up transformers consisting of several windings of coarse wire over which are placed glass insulation and a secondary winding. Such may be of the d'Arsonval, Oudin, Tesla, or various modifications of these types, as now in use under the general appellation of "high-frequency apparatus," and are employed both with the static-induced current and coils. The discharges thus derived greatly intensify the voltage and produce discharges peculiarly painless when administered to the surface of the body from one side of the apparatus. As therapeutic measures they have not been shown to be of great value, except in superficial condi-

tions. In the writer's experience, there are few indications which are not equally well met by the employment of the brush-discharge or high-frequency discharges from the glass or vacuum tubes.

If currents passing between two poles are to be desired of *great* frequency, high potential, and small quantity, or of *small* frequency, high potential, and small quantity, there is no current, with the aid of various Leyden jars and transformers,

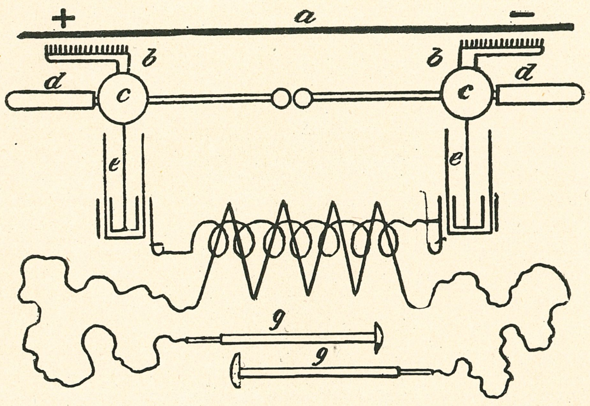


Fig. 33.—*a*, Revolving Plate; *b*, Collecting Combs; *c*, Prime Conductors; *d*, Discharging Rods; *e*, Leyden Jars; *g*, Electrode.

more rich in the possibilities of variation than the static-induced current.

Static currents are currents of *high potential* and *small quantity*, and have the frequency of oscillation under the control of the operator. They are safer than the currents of the d'Arsonval apparatus and to be preferred, unless for some reason a greater amperage may be demonstrated to be of advantage. To the writer this very action, not a characteristic of currents of small quantity, is the objectionable feature of the currents of the d'Arsonval apparatus, except when used with vacuum tubes, and places them in the same category with medicines which are designed to benefit one condition, but require most careful watching lest more mischief than good result.

The static-induced current, except when conditions requir-

ing quantity, if there are such, enter as a factor, is the most adaptable of all *two-pole currents*. (The term *two-pole current* is employed here as in preceding pages, in a relative sense, and is used in contradistinction to the wave-current, in which but one electrode and one polarity are employed, the dielectric, the air, except when saturated with moisture, conducting away but a small part of the electricity.)

A one-pole current, as the wave-current will be considered, is a current of charge and discharge—an oscillating current in which there is but one connection from the source, the patient receiving a positive or negative charge at the discretion of the operator. *Two-pole currents* pass between the electrodes, the major part by channels of least resistance, varying in the extent of tissue electrified with the amperage and the amount of potential utilized. *One-pole currents*, surging from electrode to surface, electrize the whole body of the patient.

Static electricity, when at rest, surrounds the surface of bodies said to be charged. To reach such surface in its surgings it takes the shortest route, as do all currents. It passes through the relatively homogeneous moist alkaline tissues of the body, which are good conductors, and not over the dry skin, which is a poor conductor, the relative conductivity being about as one is to one hundred. From the surface of contact with the electrode, electricity radiates in every direction to the surface of the patient and back, with each charge and subsequent discharge. To the activities excited in cell protoplasm, both the mechanical, as of a breeze passing through the leaves of the trees, and the electrical, whatever they may be, are undoubtedly due the remarkable nutritional effect of the *one-pole current*. But there is another physical effect of a conductive discharge received upon a small area, without a means of exit by a continuance of the metallic circuit. It is as though a stream of water under high pressure had been suddenly projected against a resisting surface. If an electrical discharge of an immense potential is received upon a small resisting portion of the skin of the body of the patient who is insulated and placed in the path of the current, the impact at the surface of discharge will be marked, producing a local vibratory effect.

The intensity of the effect will depend upon (1) the resistance of the skin, which diminishes as it becomes moist, (2) upon the size of the surface receiving the discharge, (3) upon the potential of the current, and (4) upon the conductivity of the tissues beneath the resisting integument. So different, then, are the conditions and effects of currents having a receiving and discharging electrode, and those having but the receiving electrode, that there are reasons to expect different results. And different results are certainly obtained which are now awakening new interest in electro-therapeutics.

The wave-current (quoting from the paper of Dr. Morton read before the American Electro-Therapeutic Association,

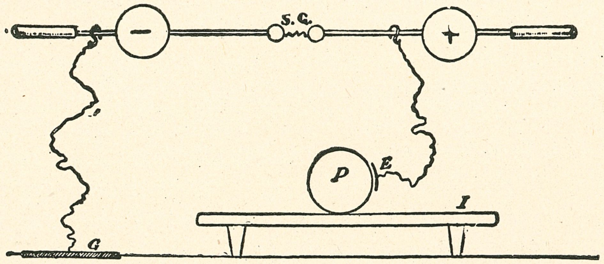


Fig. 34.—*I*, Insulated Platform; *P*, Patient; *E*, Electrode; *G*, General Connection; *S. G.*, Spark-Gap.

September 23, 1900) "was first so termed because its circuit to be completed produced Hertzian waves emanating from the patient's person." (See Frontispiece.)

The current was first published in the Bulletin Officiel de la Société Française d'Electrothérapie of January, 1899, and later in the Electrical Engineer of March 4 of the same year, and by the writer both in the Medical Record of March 3, 1900, and in the Transactions of the American Electro-Therapeutic Association for 1900.

The connections to produce this current are given in Fig. 34.

"A very important modification of this method is shown in the next illustration (Fig. 35).

"A metallic foot-plate, upon which the patient's bare feet rest, is connected by a rheophore to an extraneous and inde-

pendent insulated capacity. I generally employ for this attachment a zinc plate, two feet by five feet in size, supported upon insulated tripod legs. Any other metallic electrode, in any other situation upon the patient's person, may be substituted for the metallic foot-plate." *

The wave-current may be intensified and varied by employing an "external insulated capacity," as suggested above,

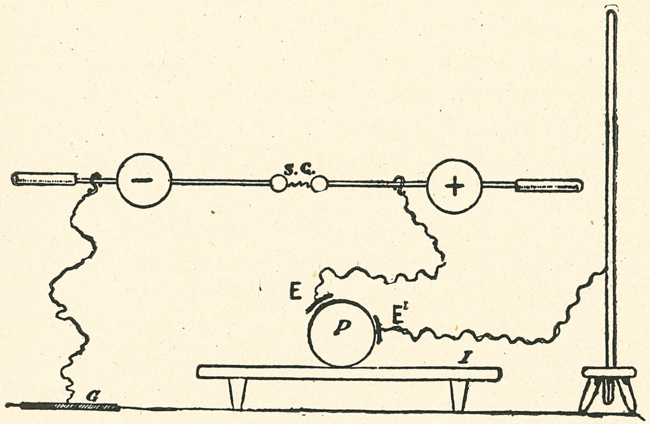


Fig. 35 —*I*, Insulated Platform; *P*, Patient; *E*. Electrode; *E*¹, Second Electrode; *G*, Ground Connection; *S. G.*, Spark-Gap.

and by making different connections employing a single Leyden jar.

I. When it is desired to intensify or localize the current by employing an "external insulated capacity" (see Fig. 35) it may be accomplished in the following way: (1) A metal sheet is suspended upon an insulated stand or by insulation material, as a cord, from the point of the standard electrode, to which a rheophore passes from an electrode placed upon the patient, who has previously been connected by an electrode and rheophore to the machine by the usual method of administering the wave-current. (2) By making use of a chair having glass castors or other insulation (as telegraph insulators) beneath

* The above, including cuts, was taken, with Dr, Morton's consent, from the report of Transactions of the American Electro-Therapeutic Association for 1900.

the legs, the chair placed upon the insulated platform, the patient being seated on the chair with feet placed upon the metal plate which is placed upon the platform, the patient at the same time having the usual connections for application of the wave-current.

II. A current of remarkable potency may be produced by modifying the wave-current, as follows: The usual connections having been made, and the electrode placed upon a surface requiring an intense local application, place a second electrode or plate indifferently on any part of the body or on a part requiring a milder local treatment, and connect the latter electrode or plate with the inner coating of a Leyden jar, the outer coating of which is connected by direct metallic connection with the earth. The spark-gap between the balls of the discharging rods will be employed to control the current strength.

With these currents, above described, the intensity of effect produced upon the patient is greater on the side connected with the machine than on the side connected with the "external capacity," or the Leyden jar having a ground connection from the outer coating.

In these modified currents, the administration is made with the patient insulated, and the effect is local to a marked, and constitutional to a very moderate, degree. Whereas the unmodified wave-current is constitutional in a very large measure, but requires more energy in the static machine to produce the same degree of local effect.

The intensity of these currents may be varied with the size of the "external capacity," the size of the Leyden jar, the size and proximity of the electrode, or the length of the spark-gap and the speed and capacity of the machine.

The writer became familiar with the wave-current during the summer of 1898, while in charge of the office and clinic of Dr. Morton, and was so favorably impressed with its effects that he began its more general adoption in the office and clinic, where it has since been in general use. It has steadily grown in favor with those who have become familiar with the correct method of employing it. During the winter of 1898-99, the writer in his private office discovered the two most remarkable properties of the current which have now been verified in the practice of many physicians; i. e., *the lessening of hyperæmia and congestion and the consequent relief of local pain.*

There are various factors and accessories to be taken into consideration if satisfactory results are to be obtained from the administration of the wave-current. The essentials of correct technique calling for special consideration are the insulated platform, size and character of electrodes, character of the grounding, polarity, length of spark-gap, etc.

I. The insulated platform should be provided with glass legs (glass has been demonstrated to furnish the most perfect insulation) at least nine inches in length if a machine of sufficient capacity to give the best results is employed. The platform should be placed at least three feet from the machine and surrounding objects should be removed to prevent the escape of electrical charge.

II. The rheophore or cord connecting the electrode with the machine should always be taut to prevent leakage to surrounding objects, and is best made of uninsulated copper wire of convenient gauge, because it may be fastened to the electrodes and passed beneath the clothing upon the surface of the patient without causing the burning sensation produced by insulated rheophores.

When, however, it is desirable to convey the current to another room it is necessary to use well-insulated wires.

III. The electrodes to be employed with this current call for consideration as to details respecting their application.

(1) **The position of the electrode** must be in close contact with the surface treated. Intervening material—as clothing, a small cord, or loose scales of epidermis—will cause an unpleasant burning sensation from the passage of innumerable short sparks through them to the surface. The dry skin requires, in a less degree, consideration. This is especially true of "the exposed portions of the neck," * which may be moistened, or

* Dr. Lucy Hall-Brown in the Journal of Electro-Therapeutics for February, 1901.

when beginning the administration employ a short spark-gap, and, after a few minutes, as the skin becomes moist, separate the balls to the distance indicated for the treatment of the patient.

It is well that the electrode applied should be either secured with bandages firmly held by the patient, or by placing a pillow where pressure would hold it in close apposition. Always place a pillow at the back when using the long spinal electrode, and use a chair having a high back, as it is often desirable to place an electrode upon the neck.

(2) **The size of the electrode** is a matter of importance and will be governed by the capacity of the machine at the time of the administration, and the effect sought. During periods of humidity, or when, from neglect, the capacity of the machine is lowered, it will be found necessary to concentrate the energies of the current; the electrode used then must be relatively small. It is possible to make only general rules to govern the size of the electrodes, which must depend upon the part treated, the patient, the kind of apparatus, and the lesion. When applied to the muscles of the thigh, leg, or trunk of an adult, an electrode should not exceed twenty-four square inches in size for a spark-gap of four or five inches, and may often be advantageously used with the same spark-gap, when of not more than eight square inches. Muscular contraction or pain over an inflamed area will determine the length of spark-gap relative to the size of the electrode to be employed.

(3) **Special electrodes** for treating the mucous surfaces of the open cavities are required; or various metal sounds, specula, etc., may be utilized in many cases. (These will be considered in chapters on special therapeutics.)

(4) **The material of electrodes** must be of some good conducting substance, preferably of metal. Sheets of soft metal * of suitable thickness may be easily cut with scissors into any desired shape and molded to the surface.

We employ two thicknesses—22-gauge for electrodes, because it has sufficient rigidity to permit it to be pushed beneath the clothing; and keep it in close apposition in all cases when molded and applied to the surface.

* A better and cheaper material than block tin is Crooke's Composition, manufactured by the John J. Crooke Company of New York and Chicago.

Tinsel or tinsel braid, such as is used for trimming (preferably the cheap article used by stage costumers), serves an excellent purpose, and may be applied as a bandage to fingers and to the limbs of children.

IV. A good ground connection when using the wave-current to the pole not connected with the patient is imperative if any but the mildest effect is sought, as may be the case when treating the eye, ear, nose, or throat, when it may be made less severe and graduated without becoming too intense to be borne by not grounding.

V. The polarity of the current, as has been demonstrated, does not especially affect the results of administration, in many cases. But it is noticeable that, under the same conditions and with the same length of spark-gap, there are always about four times the number of oscillations from the positive side, the negative being grounded, than from the negative. The maximum spark-gap, when the negative is grounded, is also slightly longer than when the positive is grounded, other conditions being the same.

It has been observed in the treatment of inflammatory conditions that the negative connection for this current is sometimes distinctly irritating, and there are no indications of the selection of this polarity for any administration. It is, however, the pole employed with the high-frequency glass vacuum electrode.

The positive pole, therefore, is preferred in applications of the wave-current, because, other things being equal, it is more sedative, and produces the best tonic effects.

VI. The length of the spark-gap (the distance between the balls of the discharging rods) measures the resistance overcome by each discharge, and, consequently, the pressure, or electro-motive force, exerted upon the patient when insulated.

The possible maximum length of the spark-gap at the time of administration will depend upon (1) the capacity of the machine, which will depend upon its condition, type, speed, and

the diameter of the revolving plates; (2) the condition of the atmosphere; (3) the character of the insulation (see Insulated Platform); (4) the proximity of surrounding objects; (5) the physical characteristics and clothing of the patient, his size and the presence of many points, as hairs, allowing a greater escape of electricity.

VII. The patient before administration, if a female, should remove her hatpins. It is best for patients who are taking electro-static treatment to use bone or rubber (not metal or celluloid) hairpins, as the metal ones may cause unpleasant sensations which annoy timid patients, and the celluloid pins have been known to ignite from a strong spray or brush-discharge. Rubbers should also be removed before the machine is started. It is always well to advise patients to remove their watches, for, though rarely, they are certainly sometimes affected by the currents.

The patient should be placed in a comfortable position, if the treatment is to be long, and great care taken that the spark-gap is gradually opened when starting the machine at the beginning of the treatment; or, what is more important to observe, because it is more likely to occur, is that if for any reason the machine is stopped during the administration and again started, or the speed accelerated, the passage of single or infrequent long sparks at the spark-gap does not occur, because they produce very unpleasant sensations of shock. Consult the patient's comfort always and employ no administration producing painful muscular contractions or severe pain, when treating inflammatory areas. If the noise of the discharging spark annoys the patient, which it rarely does, make use of the muffler. (See Fig. 12.)

VIII. The static-induced current (1) produces more pronounced local effects, other things being equal, and requires relatively less capacity in the machine, the short spark-gap, and slow speed, making them especially valuable to those having inferior machines; (2) to all during periods of humidity; (3) to those depending upon hand power for exciting their currents; (4) in all cases where very large areas require the application of powerful currents, and (5) when it is desirable

to localize the effects between two electrodes. Electrodes may be employed in connection with one or more joints requiring the same degree of effect connected in series, and the other large electrode placed upon the back or abdomen, or some part requiring more or less potent effect, as the case may be; or the electrodes may be placed upon opposite sides of a region of the body requiring treatment (care being taken that they do not come in contact), for the purpose of localizing the effect within the intervening structures. When for any reason a more or less powerful effect is desired at either electrode when employing the static-induced current, it may be regulated by placing a smaller Leyden jar to a part requiring less effect or a larger one to a part requiring less. The application of this principle will be found a great convenience in regulating the action of the current to different regions of the body.

Time will determine the relative value of the various static currents, but we believe that, except for the advantages indicated, the unmodified wave-current described in this chapter must be preferred; for its remarkable effects upon the general nutrition are due, not alone to intensity, but to the great amplitude and vigor of the administrations.

CHAPTER IX.

PHYSIOLOGICAL ACTIONS OF THE VARIOUS STATIC MODALITIES.

FRANKLINISM has in it little or no element of danger, and is therefore, the choice of all electric forms of administration to be put in the hands of the novice, for he can do no injury to the patient, and, if fairly cautious, as he is certain to be, will do some good.

Many neurologists consider the static modalities as "suggestive therapeutic placebos," which they are, in cases amenable to such influences, but they are more. Safety does not preclude the possibility of potency; as is demonstrated from exceptional results obtained in the treatment of conditions not so effectively relieved by any other measure, such as rheumatoid arthritis, sprains, and the forms of neuritis.

Compared with the constant current, the chemical action and transition of *ions* is insignificant with the static modes of application. Electrolysis, cataphoresis, and cauterization where indicated, are practically impossible to obtain with Franklinism.

The interrupted and vibratory influences of oscillatory currents of *small quantity, high frequency, and great potential,* which are administered to the patient while insulated and in a state of so-called charge, are peculiar to the Franklinic forms of administration, and the effects differ, from this fact. The action upon metabolism of vibratory influences has long been recognized by physiologists, such as that attributed to the heart's impulse. Dubois-Reymond taught "that the nutritional effects depend not on the quantity of the electricity, but upon the variations in the quantity, and the suddenness of these variations," which is true, but requires qualification in the matter of quantity and other features of administration.

I. The current should be possessed of the maximum power

of diffusion consistent with safety, which quality is peculiar to currents of great voltage and small quantity.

II. That its effect upon organic structures must be to induce functional activity, without altering their natural characteristics.

III. That the oscillations of charge and discharge must be administered to the patient while insulated.

IV. That administrations should be regulated in frequency, dosage, and duration to the demands of individual conditions.

We believe that it can truly be said that the only modalities that can produce such pronounced nutritional effects are currents of high potential administered to the patient when insulated. In other words, no form of application employing an electric circuit between two poles, labile or stabile, can produce as satisfactory a constitutional effect as high-potential currents of small quantity alternately charging and discharging during the administration; the patient being insulated and connected to one side of the source of electrical energy, the other side of which has a direct metallic connection to the earth, because no other currents can be so widely diffused and induce such activity without danger to the tissues.

The static modalities fulfill the above conditions better than other known forms of administration. So slight are the constitutional effects upon the normal individual that a study of the action in health affords no chance of making deductions which will form a basis for therapeutic indications. It is, therefore, necessary to study the effects under the different conditions and from them draw conclusions.

To avoid confusion it is best to classify the effects as local and constitutional and consider the several actions of the various forms of application.

The local effects of the wave-current considered from the actions on the normal individual and the clinical effects when applications are made to abnormal conditions are as follows:

The *local* and the *constitutional,* which vary with the different forms of administration. The local effects are: (1) a sense of vibration of the structures beneath the electrode, and also of the hairs upon the head and other portions of the body;

(2) muscular contraction; (3) physiological tetanus, induced by currents applied to sensitive regions, as of the hands or arms, increased by lengthening the spark-gap, or accelerating the speed of the machine; (4) increased secretion of sweat, beneath the electrode.

In addition are the valuable clinical effects: (1) local congestion is relieved, often with marked diminution of swelling and pain; (2) relief of local pain, or tenderness arising from many causes, is marked; (3) relaxation of acute muscular spasm not of central origin; (4) increased local metabolism and acceleration of the processes of repair if conditions are sluggish.

Sparks are in many conditions superior to the preceding, but in the aggregate cannot be considered as equal. The effects locally applied are as follows: (1) a stinging sensation, accompanied by muscular contractions following the spark discharge; (2) at the point of discharge a blanched spot appears, due to contraction of the superficial capillaries, which is followed, in a short time, by marked redness, that soon disappears, except in weakly patients. In such the effect may continue for twenty-four hours. (3) Wheals, or even blisters, may be produced when sparks are administered successively to the same spot. (4) Sparks, like the wave-current, increase local secretion and general metabolism. Clinically sparks also (1) relax muscular spasm; (2) sedate pain; and (3) lessen hyperæmia and congestion. As a diaphoretic, and applied to muscular spasms and rigidity, and also in their general massage effects, sparks excel every other modality.

The brush-discharge, like the two preceding, though to a less degree, (1) increases secretion and activity of the end organs; (2) it is rubefacient and (3) antiseptic; and, clinically, (4) sedates pain, (5) lessens hyperæmia and congestion. The sensation produced is as if hot sand were thrown with considerable force against the parts.

The breeze and spray, which differ only in degree, produce a cool or warm sensation to the surface, varying with the proximity and the character of any material which may intervene. Non-conducting materials, such as paper, woolen cloth, or silk, increase the intensity of the convective discharges. The physiological effects are much the same as those of the brush-discharge, but distinctly more irritating and less effective.

Of the static-induced current the local effects are as follows: (1) muscular contraction or physiological tetanus is produced, varying with the length of the spark-gap or the characteristics of the muscles to which it may be applied to respond; (2) local congestion and pain are diminished, but much less than with the other modes of administration.

This modality has been employed by some experimenters in connection with a step-up coil, which produces effects characteristic of extremely high frequency. These effects, however, have not been demonstrated to be essentially different from those produced by the brush-discharge and the high-frequency effects of the Geissler and vacuum tubes.

The constitutional effects observed, when static electricity is administered to an individual in health, are practically *nil*. To those, however, in whom there is a departure from the standard of health, from either functional or organic derangement, the effects are most pronounced.

I. The effects upon the circulatory apparatus are: (1) general lowering of arterial tension; (2) lessening of the frequency of the heart's action, with (3) lengthening of diastole, and (4) increased volume of the pulse.

II. Respiration (1) becomes less labored and less frequent; (2) deepens, and (3) there is found at the same time to be an increased elimination of CO_2.

III. Nervous irritability, if the opposite conditions be present, is relieved to a marked degree.

IV. The soporific effects are such that patients invariably become drowsy, and often fall asleep during the administrations, sparks excepted. Especially is this true of the wave-current or interrupted insulation.

V. Lassitude may be produced by prolonged administrations.

VI. A general diaphoresis is induced in most patients, if sittings are from ten to twenty minutes, with the wave-current,

interrupted insulation, or the convective discharges. No therapeutic measure in normal individuals will induce a general diaphoresis so promptly and without depression as a thorough application of sparks, long and friction.

VII. Inactive secretions and excretions are more or less induced to activity during a course of either local or constitutional administrations. So remarkable are these effects that patients receiving prolonged treatment for a local trouble invariably show marked general resumption of functional activity to organs not impaired by organic derangement. Especially marked is the aggregate increased elimination of solids with the urine in rheumatic and gouty patients and in those in whom from any cause metabolism has been defective.

That metabolism is increased in the end organs when a series of administrations are taken there is abundant evidence. (1) Increased oxidation is evidenced by the marked additional elimination of CO_2; (2) the augmentation of the quantity of solids in the urine, with ultimate restoration of the proper proportions of normal constituents. (3) The restored appetite and steady increase in body-weight, until the patient's normal standard is reached, are the invariable results, if derangements are but functional.

To summarize in a few words—*induced normal activity* defines the physiological effects of Franklinism, properly applied.

CHAPTER X.

GENERAL PRINCIPLES OF ELECTRO-STATIC ADMINISTRATION AND THERAPEUTICS.

THE administrations of Franklinism are governed by general principles which, when once understood, constitute a basis for correct and successful operation.

The subjects for general consideration are the patient, the dosage, and the frequency of treatment.

I. The patient who comes for the first static treatment, in this age when criminals are electrocuted, citizens killed by live wires, and buildings burned because of poor insulation, is usually in a state of trepidation, and the numbers who do not come, for the same reason, are legion. Impostors, quacks, and charlatans have made electricity a byword. It has become a subject of jest with the specialist and family physician, who as a rule know little about its use. The patient is therefore terrorized, prejudiced, and skeptical before he comes for treatment. It is then necessary to enlighten him and calm his fears at the first interview, which is easily accomplished in most cases, by explaining the absence of danger from currents of high potential and infinitesimal quantity. The administration of the treatment without blunder or accident will greatly aid in winning confidence, as well as the management of the treatment in such a manner that some degree of benefit is derived from the first application.

To convince himself that the maximum output of the machine could not kill a patient, the writer made the following experiment: A mouse was captured and placed in a paper box having one side of glass. A small hole was made in one end, and the box was then put upon a metal plate. The shepherd's crook was then connected from the platform to the machine, and the machine set in very rapid motion. Upwards of forty

very long indirect sparks were administered to the body and head of the little animal, and he still survived. That cruel experiment has served as a convincing argument to many timid patients, and fully reassured the writer of the absence of all danger.

If the patient's affection is such that vigorous sparks are necessary to relieve the suffering at the first treatment, explain that it will be painful and then proceed. The writer recalls cases of podalgia, chronic rheumatism, and sciatica in which nothing else would have given relief. As a rule, however, such heroic measures are not necessary, though they may be required later in many cases. The patient's first few treatments may then be relatively mild. Generally, however, it is not good practice to fail to make a favorable impression by giving some marked evidence of benefit in the early days of treatment, and it is rarely difficult to do so in cases to which the treatment is adapted. The first few treatments are often marked by such a degree of improvement that patients are impatient when it takes a considerable time to effect a complete cure. Accidental sparks, shocks, and surprises may occur with inexperienced operators, but are certain to lessen the patient's confidence and awaken fears and doubts which subsequent arguments and explanations may not satisfy.

The idiosyncrasy of the patient is not often a factor to be considered when administering static electricity. This is especially true of all forms of administration except the sparks, when employed (as they should be) without accidents, because there are no shocks, unpleasant sensations, or physiological effects to disturb the patient's equilibrium. Apprehension of impending danger is the only element in impressionable patients with which the operator has to contend, and this will largely depend upon whether the patient has confidence in his attendant. Under such conditions, and possibly in a few others, instead of the usual glow which accompanies the administration, there may occur a condition, which has been described by some writers, in which "the patient remains chilly, depressed, and apprehensive." In most of these patients the effect is said to disappear after a few treatments.

It is usual for patients whose secretions are inactive, such as neurasthenics, during the first few administrations not to perspire.

The skin of some patients is especially susceptible to the convective and disruptive discharges; an unpleasant pruritus appearing which may persist for several days after an administration. Wheals and sometimes blisters have followed an application of the spray or sparks. With patients in whom the circulation is not good, and the reactions are also sluggish, a treatment by sparks may be followed by a mottled appearance, which may persist for twenty-four hours and sometimes longer. Such effects cease to appear as the general health of the patient is restored.

When the dosage and form of administration are once regulated to the physical and local conditions of the patient, and the harmless character of the application is fully explained, the number to whom the currents cannot be administered will be small indeed.

II. The dosage, the amount of current or other form of administration to be employed, and the length of time devoted to the treatment or the number of sparks to be applied, can only be regulated by clinical experience and the study of individual requirements. To obtain a positive impression, generally, for either local or constitutional effects a minimum of fifteen minutes is required when the wave-current or either form of electrification is employed; and the best results often demand thirty minutes.

An over-dose or too prolonged treatment may be followed by weariness and a sleepy condition, never dangerous and always relieved by rest. When employing sparks, be governed in acute painful conditions by the relief afforded. If at first the improvement is but partial, and the patient does not object, persist until relief is complete, or at least nearly so; taking care to give no careless or unnecessary sparks, but applying them directly to the lesion, where they are certain to be the most painful. The patient soon discovers that sparks so applied are followed by greater relief, and enters into the spirit of the treatment and directs the application to such points. It

is well, however, to remember that sparks when applied to bony prominences or motor points are always painful.

In each case be governed by the results of previous administrations, and regulate the dose to the individual as in other methods of medical practice. The patient's say-so in the matter of dosage is more to be considered in this than in any other kind of medical practice.

III. The frequency of administrations is of the greatest importance, and the writer is convinced that the oft-repeated remark of those who have carefully employed static sparks, that "the relief is only temporary, and does not cure," is due to want of thoroughness from lack of appreciation of what is taking place, and failure to again administer the treatment before a complete relapse has occurred.

Bridging is the term the writer has employed to express the timely repetition of treatments to prevent but partial relapse of the condition relieved. Whether treating a painful or inflammatory condition, or a case calling for a tonic effect, *the golden rule is to bridge the condition of relief from treatment to treatment, lessening the frequency as the requirements permit.* Rarely will this rule call for more than one treatment in twenty-four hours. Occasionally, however, in acute inflammatory conditions, two treatments daily may be required for a few days. When employing Franklinism to obtain the nutritional effects, best results are derived from daily administrations for the first two to four weeks, to be determined by the progress of the case.

The knowledge of the physiological actions and effects of the different forms of administration suggests to the physician a large range of therapeutic indication, and in a general way the choice of modalities. There are, however, definite methods which experience has demonstrated will produce the best results. A classification is adopted in these chapters which groups the conditions with reference to types having similar indications for treatment, without reference to the ordinary classifications in text-books. This is done for the purpose of suggesting to those unfamiliar with the static methods like indications for their employment in similar affections.

By thus particularizing in a number of cases, which demonstrate the various effects, the special applications will suggest themselves to the reader.

So numerous are the diseased conditions associated with *hyperæmia* and *congestion,* and so certain are the demonstrations that they are relieved in a large number of cases where no other means are so effective, that it is more difficult to discriminate in what case electro-static methods are not indicated than to discover indications for their use.

Paralysis and spasmodic conditions, not of central origin, have been benefited in all recent chronic cases. This is true in peripheral painful neurosis, atrophies, anæsthesia, and functional disorders in general.

When errors of secretion or excretion exist, the prognosis will depend upon the condition of the organ in question. If the derangement is but functional, the prognosis will be good in most cases. Presumptuous as these statements will seem to many, let it be borne in mind that static electricity, scientifically applied to the human organism, is the *sine qua non* for activity, not of one cell, but of all, not of one organ, but of all organs.

Equilibrium, to be restored, requires only properly regulated frequency and dosage, together with proper adaptation of food, habit, and environment. Functional derangements are cured and patients recovering from protracted fevers have their convalescence materially hastened.

CHAPTER XI.

THERAPEUTICS OF INFLAMMATORY CONDITIONS.

PATHOLOGICAL conditions are characterized to a greater or less degree by congestive or passive hyperæmia. Irritants enter the economy, or are produced from defective action within the organism, and induce local congestion.

Pathologically considered, hyperæmia arises from circulatory disturbances due to pressure, traumatism, obstruction, or paralysis of the muscular coats of the vessels, of which one type, at first passive, may become active or congestive. The other type of hyperæmia is active, leading on to congestion in its early stages. These are induced by traumatism, exposure to heat or cold, the presence of germs, tissue necrosis, or of other sources of irritation to which the parts are subjected.

"When a strong stimulus acts upon a muscular part, hyperæmia, redness, and swelling occur. In congestive hyperæmia under the microscope we see (1) dilated blood vessels overfilled with corpuscles; (2) the stream becomes irregular and slower; and next (3) stasis occurs and the blood vessels are plugged. During these processes, the white corpuscles, and, less often, the red, escape into the tissues, plasma exudes, and swelling results. Under favorable conditions the stasis may disappear." *

If the proliferation is not deferred on account of the intensity of the inflammation, regeneration, which takes place in cases in which the congestion is mild in from eight to twelve hours, will be established permanently and without hypertrophy. If, however, the stasis is allowed to persist, tissue necrosis results and repair may be long deferred.

The processes of regeneration are often delayed by one or

* Landois and Stirling: "Text-book of Human Physiology."

more of the following causes: (1) the exciting cause may still be present; (2) the inflammation may be intense and the stasis and swelling persist; (3) the lymphatics may be inactive and slow in removing the products of inflammation; (4) the exuded fibrin and degenerated blood cells may be deposited in the vicinity of structures not well supplied with lymphatics, as so often happens in the joints, and there remain, producing anchylosis or other impairment of motion; (5) the presence of micro-organisms which develop characteristic tissue change and degeneration, delay restoration, and, if not removed eventually destroy the part; (6) there may be retained necrosed tissue, as dead bone; (7) in diathetic diseases, it does seem that irritants have either accumulated at the site of the inflammatory processes or are being constantly poured in.

In both types of hyperæmia, the indications are apparent. That electricity of great potential, high frequency, and small quantity removes obstacles to regeneration and promotes normal tissue proliferation can be demonstrated both by analogy and experience.

The properties which effect the results to which we will refer are mainly due to the intense penetrating vibration and consequent induction of contraction of the muscles and structures surrounding the congested area and the coats of the circulatory apparatus at the site of administration—which actions are peculiar to electricity. The local vibratory or interrupted contractions, as of the hand upon the bulb of a Davidson's syringe, give the impetus which starts on the blood stream and overcomes stasis, and we are certain that no other mechanical agent can produce the degree of intensity, frequency, or penetration which we obtain from the static machine which has the frequency and amplitude controlled by a spark-gap. in association with a current output that can be increased or diminished. Nor has any other interrupter or mechanical vibrator been constructed for use in connection with electrical apparatus which will modify all the qualities of fineness, amplitude, and frequency as well as that produced with the spark-gap and a regulated current output.

That the electrical action of the currents, electrolytic, cata-

phoric, or electro-chemical, are not essentially of value in relieving these conditions, we believe is proved from the fact that the best results are obtained from the currents that possess those qualities in the least degree. That an energizing, stimulating effect upon cell protoplasm is derived from these currents which is not due to vibration, there is abundant proof from the general sense of well-being that follows an administration. Nor are the effects caused by the well-known electrical actions above referred to, as is proved by experience. It seems more likely that an influence effect by polarization of the tissues, without altering the cell structure, creates normal action which, in accord with nature's law, leads to regeneration and restoration.

The induction of local activity by overcoming stasis, and general by restoring the normal balance of the metabolism, contributes in all inflammatory conditions to the removal of the cause, and to tissue proliferation with regeneration.

Clinical experience with many conditions has demonstrated the following facts, which it is difficult for controversy or argument to weaken or disprove:

Electro-static modalities (1) remove stasis; (2) promote absorption of plasma and other detritus, thereby (a) lessening pain and swelling, (b) removing deposits of fibrin and disorganized blood cells in the vicinity of joints, (c) inducing the reabsorption of organic and inorganic salts which have become locked up in the tissues as a result of defective metabolism. (3) They produce a general equalization of the blood currents to all parts of the body with well-marked lowering of arterial tension, which decidedly lessens the possibility of local congestion; (4) there is positive proof that a local expression of blood from the vicinity of the lesion takes place by the production of *mass* contraction and *contraction of the walls of the arterioles;* and (5) regeneration and restitution are hastened.

The relief of passive hyperæmia occurring with marked œdema in organic disease of the liver, heart, and kidneys, and in cases of varicose veins, resulting from thrombosis of the large veins of the lower extremities, offers but little encouragement from electro-static treatment. Those arising, however, from lost tone of the arterial or venous walls, functional derangements of some part of the glandular system, pressure due to constipation, or cases associated with surgical œdema following operations or accidents, are successfully treated in all but exceptional cases by one or another of the static modalities. Early attention greatly enhances the prospects of a prompt restoration to normal, the principle *a priori* in all cases, the degeneration and structural alteration either precluding the possibility of restoration or requiring much longer time to induce a recovery approaching the normal. When a large gland, as the liver, is the seat of hyperæmia, the application of one of the modalities over the organ will afford relief.

In cases of surgical œdema, great satisfaction will be derived from the static treatment, because tone and activity are restored to the parts, active lymphatic secretion induced, and the stasis and œdema removed.

The same general action takes place in numerous other cases of passive hyperæmia, which it will be unnecessary to mention.

To the effect upon acute congestive hyperæmia we turn for the greatest triumph of modern electro-therapeutics. The same rule applies here as in all cases: Early administration insures a prompt restoration; in all others, time relative to duration, and the probability that recovery will be incomplete, or if a pus cavity has formed, its evacuation by the knife must precede or replace electrical treatment.

Therapeutically, the static modalities meet in a most complete and satisfactory manner the essential indications in inflammatory conditions not characterized by the presence of micro-organisms beneath the surface, or of some foreign or necrosed substance which cannot be promptly absorbed.

The modalities of particular value in influencing these conditions are the wave-current, the static-induced current, the brush-discharge, sparks, and the spray, which produce the following effects:

1. **Throughout the economy,** normal functional activity is induced, associated with the maintenance of the nutritive and secretory processes.

2. **Stasis,** the first disturbing influence to the processes of repair, is promptly removed.

3. **In acute cases the exudate,** which may have accumulated, is absorbed, and the swelling often largely disappears during an administration.

4. **In chronic cases, fibrin** and other products of inflammation which are deposited in the tissues, as they are especially apt to be in the vicinity of joints, are gradually separated, when not too deeply situated in the structures of the joint, by the vibratory action of the wave-current, or still more effectually by the long percussion sparks.

5. **Healthy active metabolism** is induced and the processes of cell proliferation and restitution are undoubtedly accelerated.

6. **When indolent or irritable ulcers,** or affections associated with the growth of bacteria, are present in the skin, remarkable anodyne, oxydizing, and stimulating effects are derived from the administration of the brush-discharge.

7. **There is marked lowering** of the general arterial tension, which is most prompt when sparks are administered and most prolonged after an administration of the wave-current.

8. At the same time there are locally induced by the wave-current, sparks, or brush-discharge a mass contraction and a contraction of the arterioles in the structures immediately beneath the surfaces, with marked diminution of local congestion.

9. **Prolonged administration of the brush-discharge** or the spray produces beneficial rubefacient effects.

10. **Pain promptly disappears** from the first, and will not return if administrations are sufficiently frequent to control the congestion.

That these effects are produced is demonstrated daily in the experience of those who make correct use of the modalities.

For convenience of classification, the inflammatory conditions will be divided into (1) those characterized by the presence of micro-organisms, either demonstrated or suspected; (2) those due to tissue necrosis; (3) traumatic affections, with and without solutions of continuity; (4) those arising from some dyscrasia, cachexia, or diathesis; and (5) those arising from functional inactivity and unknown causes.

I. Germ life, like other forms of cell protoplasm, is but slightly affected by the static forms of administration, except those with which ozone is brought in contact, and their vitality destroyed by oxidation. Such administrations are applied with difficulty and uncertainty to all but superficial lesions, which will be treated in a chapter devoted to diseases of the skin. In tuberculosis the bacillus is not destroyed, except superficially, by any direct effect of the static modalities upon the germs, either by cataphoresis or ozone within the tissue, because it is physically impossible to bring ozone in contact with germs beneath the integument.

II. Ozone inhalations are advocated by some authorities for the treatment of tuberculosis. It must be borne in mind, however, that when high-potential electrical discharges take place, decomposition of the atmosphere results in the production not only of ozone, but also of nitrous acid (NO_2), which is an irritant and probably likely to do harm. It has been said, however, by an eminent authority that "possibly nitrous acid was what affected tubercular patients so beneficially."

That static tonic administrations, however, do assist in curing incipient forms of phthisis, by restoring the general health of the patient and thereby removing the lowered conditions essential to the growth of the bacillus, is unquestionable.

III. Sprains and bruises, not complicated by fracture, severance of ligaments from their insertions, muscular ruptures or lacerations of the integument, severe though they may be, yield more promptly and completely to electric treatment than to any other. The wave-current, the brush-discharge, and sparks are the effective modalities. The wave-current should be administered to the surface surrounding the joint by placing the metal electrode in close contact, after which the length of the spark-gap should be regulated to the conditions, employing always as powerful currents as can be used without producing painful contractions of the muscles. Continue this treatment for from fifteen to twenty minutes, bearing in mind that the longer time is sure to be effective, while less would

often not suffice. In some cases the wave-current will be all that is required, in others the administration of the brush-discharge, employing the wooden ball electrode, will still further remove superficial tenderness or swelling. Some cases, especially those about the face and hands, in which the tissues are not dense and deep and the small muscles contract painfully to very mild applications of the wave-current, can be completely relieved by the application of the brush-discharge, for from ten to twenty minutes, the time depending upon the severity of the case and the extent of the area affected. When applying the brush-discharge it must be constantly moved about, or its application will otherwise be unbearable.

When the deep structures of large joints are involved, or with very stout patients, it will often be necessary to employ long sparks directly to the affected region. The indication for the application of sparks will be the persistence of pain on motion, felt deep in the structures of the joint during the progress of the treatment.

The results from these methods are uniformly good. The pain and swelling will be much diminished at the time of the administration, and cases of not more than twenty-four hours' standing will be cured in from three to five days, during which time the patient should be permitted to use the part. In sprains of long standing the length of time required will vary with the characteristics of each case, but improvement in most cases will be marked and satisfactory from the first. Severe sprains, complicated by rupture of the ligament, are satisfactorily treated in the same manner, and though the time required to effect a cure is longer, progressive improvement will be marked.

When there is an abrasion in the vicinity of the sprain or bruise, avoid placing the electrode or making an application of the brush-discharge directly over the open surface, as it will be too painful, the most of the current entering the injured spot.

The treatment may be properly instituted as soon as the swelling appears and should be administered until the parts are no more sensitive to the administration than the surrounding surfaces. The frequency should be regulated to the indications of the individual case.

IV. The treatment of fractures associated with splints is of great interest, because it is possible to allay much of the suffering and hasten the complete recovery of the case. The brush-discharge is the only modality indicated, because the sparks and the wave-current cause such active contraction that the fractured parts are apt to be thrown out of position. The danger of anchylosis is greatly lessened. This feature will be highly appreciated in the treatment of fractures and dislocations in the vicinity of joints. Success in this class of cases may be directly attributed to the effects of lessening congestions, and at the same time hastening the process of repair.

V. Dislocations and all other traumatic injuries will be treated upon the same general principle and with a degree of success that will in time guarantee the general adoption of the method.

VI. In the management of the rheumatic and gouty diatheses, as well as the conditions present in rheumatoid arthritis, the results of treatment are threefold. (1) Most cases are promptly relieved of the local conditions. (2) Marked improvement follows in the patient's general health. (3) Decided increase in the aggregate of solids eliminated with the urine, as well as marked diuresis in many cases, will be noticed.

RHEUMATISM.

Medicinal treatment in the above disease, of which the ætiology is so imperfectly understood, is and always has been empirical.

In rheumatism undoubtedly, as in gout and myalgia, there are two indications for treatment—that of the diathesis and the local manifestation. In acute rheumatic fever, the indications and means for medical treatment are undoubtedly too well established to be questioned. In the rheumatic diathesis, however, all medicinal treatment seems to fail and opinions and remedies are numerous and variable, as in all diseases for which no satisfactory plan of treatment is recognized.

The associated conditions present with the rheumatic diathesis may be attributed largely to functional inactivities resulting either from physical organic defects, or improper habits of diet or exercise.

Franklinism is well calculated to meet the requirements for relieving both the constitutional and local conditions in all cases of chronic articular rheumatism as well as having proved a valuable aid to the usual methods in acute cases.

The constitutional treatment should be pursued with thoroughness because it meets so well the indications, unlocking the secretions and promoting the elimination of the accumulated products of defective metabolism, which are recognized as exciting causes of the disease. Apply the metal electrodes closely, securing them with bandages to the affected joint and employing the wave-current, regulating the spark-gap by the effects produced—pain and muscular contractions to govern the gradual lengthening of the gap. Continue each administration for at least twenty minutes. If two or more large joints are affected, or for some reason it is desirable to make an application to the abdomen, or back, or over the liver, with a view to increasing the activity of their functions, the modified wave-current or the static-induced current may be employed.

The advantages of either of the latter are that with them two or more large joints can be treated at one time, whereas with the wave-current there might not be sufficient energy to produce the desired effect upon both. Whenever it is possible to obtain enough current to treat two or more joints at one time, the wave-current should be employed because of the marked constitutional effects not produced by the other currents. It must be borne in mind that the local effect is relative to the surface area of the electrodes and the character of the structures treated. As a rule, the muscles contract in proportion to their size, other things being equal, therefore, when connecting several electrodes which have been applied to parts to be treated together, and to one side of the machine, observe that they are equally responsive to the current. When employing the static-induced current, therefore, connect several sensitive parts together to one side, employing relatively large electrodes and to the other side small electrodes to less sensitive parts. The proof that they are right will be that about the same vibratory sensation is appreciated in all parts.

It will easily be seen that by such means much time can be saved when many joints require treatment; but, to obtain the best results, considerable tact and experience will be required to equalize the effects.

To obtain the best results upon local congestion, the application should be localized and the oscillations not frequent. When there are few joints requiring treatment, and the capacity of the machine at the time is capable of producing the desired intense vibratory effects, the wave-current is to be preferred because of the tonic effects produced. In any event, one administration of the wave-current for at least fifteen minutes should be given during each sitting, for its effect in stimulating secretions and excretions is important for the relief of rheumatic conditions. The time devoted thus to each joint should be not less than fifteen minutes, and excellent reports are noted from administrations of more than one hour duration. The treatments should be daily, and severer cases require two applications during twenty-four hours.

In addition to the wave-current, sparks will be indicated when the lesions are deeply seated and chronic. No form of administration is so effective in the production of the local effects upon deep structures, and for removing the products of inflammation, as long, indirect static sparks. They are especially indispensable, and effective, in rheumatism affecting the hip, knee, ankle, and shoulder joints, and often beneficial in the smaller joints as well. Their use should, as a rule, follow an application of the wave-current.

A general administration of sparks (in lengths proportional to structures), ending with an active general friction applied very rapidly over the whole person of the patient, is a very valuable means of promoting a general and active metabolism.

Another measure invaluable in the treatment of rheumatism is the brush-discharge. It will be found of advantage in the

treatment of each case, and sufficient for its local effect in a very large number of cases. No form of administration will give greater satisfaction in any affection than the brush-discharge in many cases of acute articular rheumatism, after an administration of ten minutes, during which interval the wooden ball is moved rapidly about over the affected surface. The relief from pain is usually prompt and enduring; much swelling often disappears during the administration, and a complete disappearance of the trouble may take place in a few days. The technique is simple and requires but little skill. The material of which the wooden electrode is made and its condition are matters of the utmost importance if the modality is to be successfully administered. The literature up to the present time on the subject is not in accord with the above plan of treatment; but it has been demonstrated by the writer in an ample number of cases that electro-static treatment of young and robust adults, when continued for sufficient periods, will effectually cause the elimination of the materials which seem to induce the acute attacks. It is remarkable that in the treatment of acute cases a very marked degree of diuresis is induced.

MYALGIA.

Muscular rheumatism is one of the affections in which electricity, especially static, has long been recognized as a specific. Sparks—long, short, and friction—have held monopoly in these cases, but the wave-current greatly aids in the severer forms of lumbago, and may be wisely employed in all chronic and severe forms; as may also the brush-discharge, which very effectually meets the indications. It is possible to relieve them and therefore advisable in nervous patients to administer prolonged applications of the wave-current before resorting to sparks.

GOUT.

An acute attack of gout can either be cut short or greatly alleviated by the use of the brush-discharge, or the wave-current, in conjunction with the usual specifics. The relief afforded by an application of the brush-discharge to an acute gouty arthritis is most gratifying to both physician and patient. If the attack is acute, and it is possible for the patient to receive two treatments in twenty-four hours, during the first days of the attack, it will hasten favorable results. We believe that time will demonstrate that no plan of constitutional treatment is so well calculated to promote the elimination of gouty accumulations in the system as the properly regulated and systematic administration of static electricity; employing the same general plans advised in the treatment of rheumatism. The constitutional treatment of gout, employing static electricity in connection with dry hot air, following the same general plan prescribed above in the treatment of rheumatism, should be thorough and persevered in for months, in conjunction with a well-regulated diet, when the results are certain to be satisfactory.

ARTHRITIS DEFORMANS.

When Virchow named a class of conditions characterized by arthritis and deformity, **arthritis deformans,** he inadvertently included under one name at least four distinct affections occurring from as many different causes. They comprise two diseases commonly encountered, rheumatoid arthritis and osteoarthritis, and two others which are more rarely seen, gouty arthritis and a peculiar type which has not been named or described, to the writer's knowledge.

To rheumatoid arthritis belong all cases characterized by the presence of an anæmic and depleted condition arising in most cases from some other traceable cause. The joint process is well defined and easily differentiated, beginning with a slight pain in one or more joints which will be in most cases in the middle phalangeal joint of the finger. In some cases this pain is ushered in with great severity. A swelling soon appears in the affected joint and other joints gradually become involved. The destructive process once begun, it has been rarely known in unmolested cases to stop until the joint is permanently destroyed and anchylosed. This affection is uniformly bilateral, indicating a central origin as in locomotor ataxia.

The degree of destruction and deformity varies from fixed flexion with absorption of all the cartilaginous structures of the joint, to destruction of the articular ends of the bones, as well, in severe cases. (See Fig. 36.) The suffering and deformity

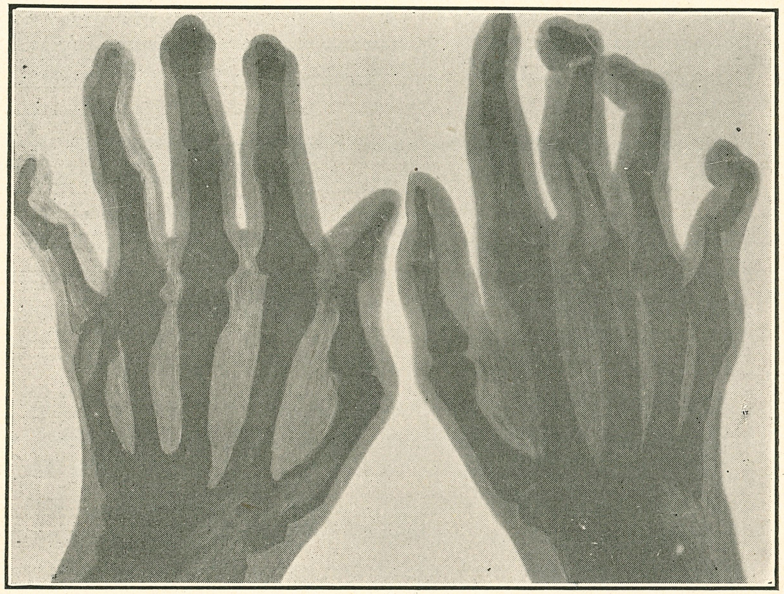


Fig. 36.

are more marked and the progress more rapid, than with the other conditions with which rheumatoid arthritis has been confused.

The changes in the bone which take place in rheumatoid arthritis in children are quite remarkable, as is shown in the accompanying skiagraph, Fig. 37. It will be noticed that the joint between the metacarpal and the first phalanx of each hand is disarticulated and that all the phalanges and metacarpal bones are wider than normal. The latter condition, we believe, takes place in all cases of rheumatoid arthritis in young children.

Once established the disease may involve many or all of the joints of the body.

It is characteristic of no age or sex; young children are affected and it may also commence in the aged. It is far more common, however, with women during active menstrual life. The case shown in Fig. 38 is that of a child seven years old. This case was reported at the meeting of the American Electro-Therapeutic Association held at Washington in 1899 and pub-

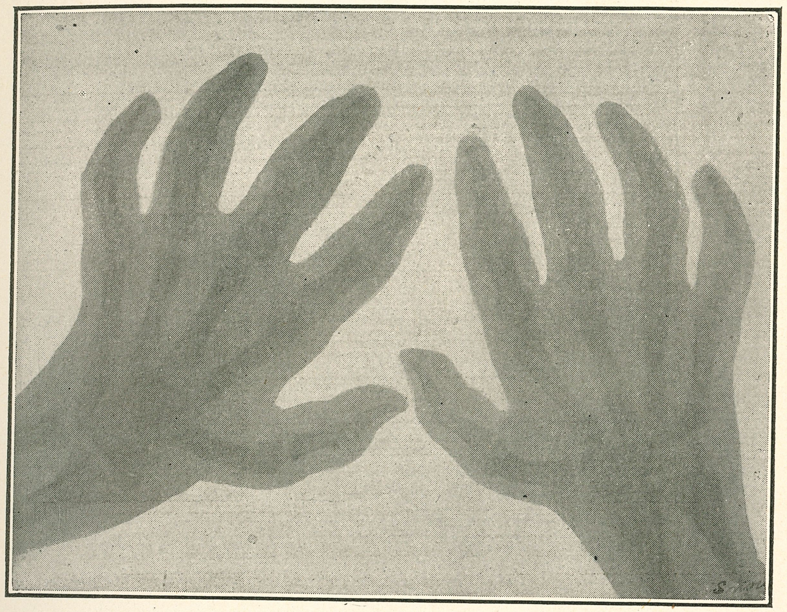


Fig. 37.

lished in the Transactions of the Association for 1899 and 1900 and in the Post-Graduate for October, 1899. The effects of the treatment upon this case, together with the favorable results obtained upon an adult patient at about the same time, led the writer to devote much attention to the study of the disease. The case shown in Fig. 39 is another instance of the manner in which the disease attacks young children.

The ætiology of rheumatoid arthritis is a question of doubt. Bannatyne and Spender adhere to the notion that it is due to a germ. This view has not, however, been confirmed by most

observers, and the writer's experience in the treatment of the disease leads him to doubt the presence of such a cause, because of the success obtained in the treatment of the disease, employing a means that does not unfavorably affect cell protoplasm or the germs known to be present in other diseases.

Fig. 38.

There is, however, abundant evidence of an affection of the trophic nerve centers from the muscular atrophy, pigmentation, absorption, and destruction of the soft parts in which it resembles to some extent the similar conditions of locomotor ataxia, progressive muscular atrophy, and allied diseases. In the writer's cases, which number more than fifty, there has in most cases been present some exhausting condition or chronic affection such as Bright's disease or syphilis, but most com-

monly some of the affections associated with menstrual derangements. This makes probable the theory that the trophic conditions which seem to cause the disease arise from malnutrition.

The prognosis is relative to the length of time that the disease has been present, to the nature of the complicating

Fig. 39.

conditions, to the extent of the affection, and to the faithfulness with which the patient follows the proper treatment.

Whenever the inter-articular cartilages are intact, as indicated by the light line between the phalanges, experience teaches that the other joint structures are also unaffected, and recovery of the affected joint will be complete; while in joints where that cartilage is more or less involved the joint can never be normal, but will remain entirely or partially stiff after the active processes are checked. Radiography has also demonstrated the absence, in every case examined, of so-called chalky

accumulations, and has diagnosed classes of cases distinct in every way from rheumatoid arthritis.

The treatment is essentially the same as the treatment of rheumatism and other inflammatory conditions. The constitutional treatment is of the utmost importance and never to be neglected. Each finger should be covered with soft metal—narrow strips bandaged about the fingers. When applying

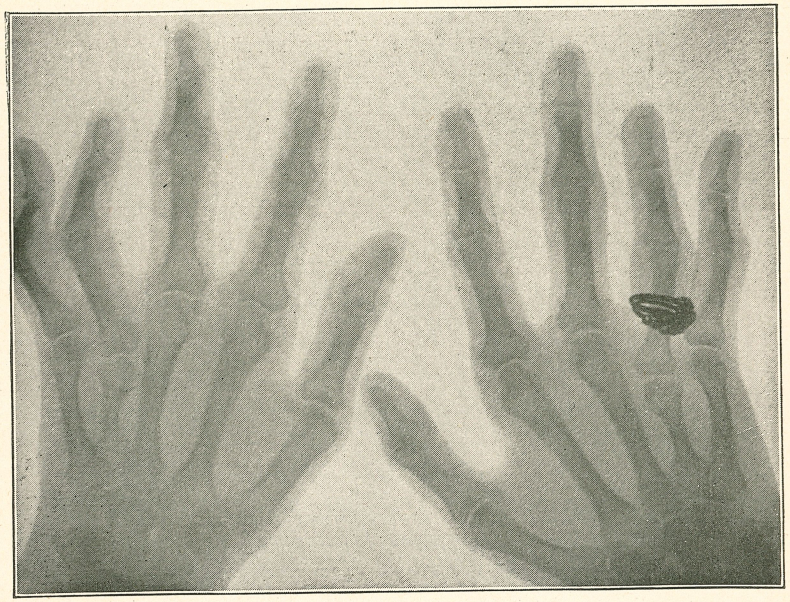


Fig. 40.

metal electrodes about large joints, the writer usually slits square or rectangular pieces (see Fig. 41), so that they may be adapted to the joints. For best results the wave-current or derived currents should be administered to each joint affected, for some fifteen to twenty minutes during the first weeks of treatment. For this purpose much time will be saved by connecting several joints for one administration. When treating in this manner, take care that the joints simultaneously treated are about equally sensitive to the current. For example, the hands, wrists, forearm, and temporo-maxillary

articulation will endure about the same current, and the shoulders, ankles, and feet a much larger voltage. As a rule the knees, singly or together, will require in an adult as much current as a machine will excite (an eight- to twelve-inch spark-gap with the wave-current). The writer has frequently employed a spark-gap ten to twelve inches in length when treating the knees with the wave-current. The longer the

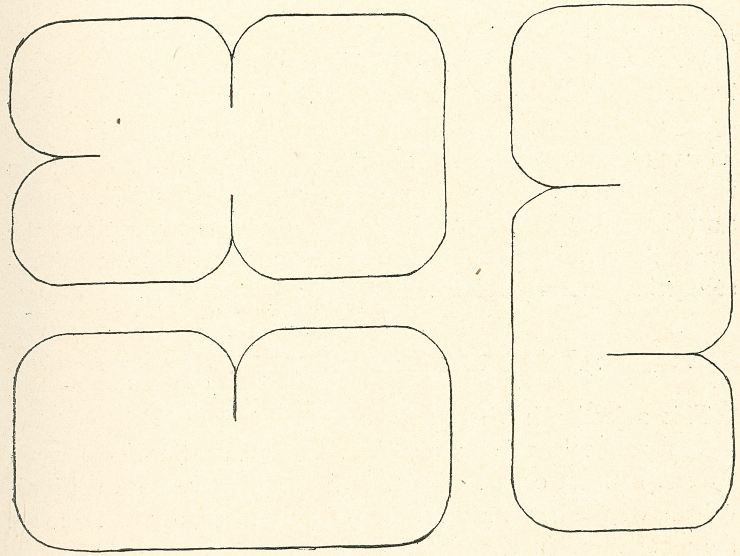


Fig. 41.

spark-gap that can be employed in every case without causing discomfort, the greater the effect upon the deep local congestion.

A very liberal application of sparks—short ones, one-half to three-quarters of an inch in length, to the finger-joints, and relatively longer ones to the other joints—is indispensable, if success is to attend the treatment of chronic cases of rheumatoid arthritis. Painful as they are, an average of about ten sparks to each finger-joint seems to be required. These are best borne when the operator takes a single spark from each joint, and, passing back and forth along the rows of knuckles, completes the required administration.

The brush-discharge affords great relief when applied to the affected joints in rheumatoid arthritis. It should be applied until the administration ceases to cause the characteristic pain occasioned by its use over inflammatory areas. It is remarkable how much relief can be afforded by this modality, and it should be employed in all cases, especially when initiating a timid patient to the treatment. It takes much more time, however, than sparks and it is difficult to say that it accomplishes more.

Patients should be treated daily until the effects will *bridge* longer periods. The intervals should not be longer than three days, until cured. The promptness with which relief follows will vary greatly with the cases. Some will be cured within two months and others will require as many years. Particular attention must be paid to the constitutional treatment and the removal or relief of the primary disease, and satisfactory results will generally follow.

OSTEO-ARTHRITIS.

This affection is distinct from rheumatoid arthritis, and has long served to confuse the professional mind and literature on the subject. It occurs usually in healthy, well-nourished individuals of the better classes, and begins to appear at or about the menopause in women, and is very rare in men.

The examination of a large number of these cases with the Roentgen ray has convinced the writer that what have so often been considered chalky deposits are true osteophytic enlargements of the bones and usually appear at the last phalangeal articulations, as shown in the accompanying illustration. It is incorrect to consider them of gouty origin, or in any way allied to gout. There is no cure for the condition when once developed. The application of sparks, as in the treatment of rheumatoid arthritis, will in most cases relieve the local pain and inflammatory swelling, and render joints otherwise painful constantly useful. The case represented in Fig. 42 has for four years received on an average two or three treatments monthly, going frequently two or three months without suffering or

treatment. The osteophytic enlargements have not increased in size, nor diminished, since they have been under observation, as is shown in the skiagraph, Fig. 43, which was taken four years later than that shown in the preceding cut.

Sparks associated with the brush-discharge give the best

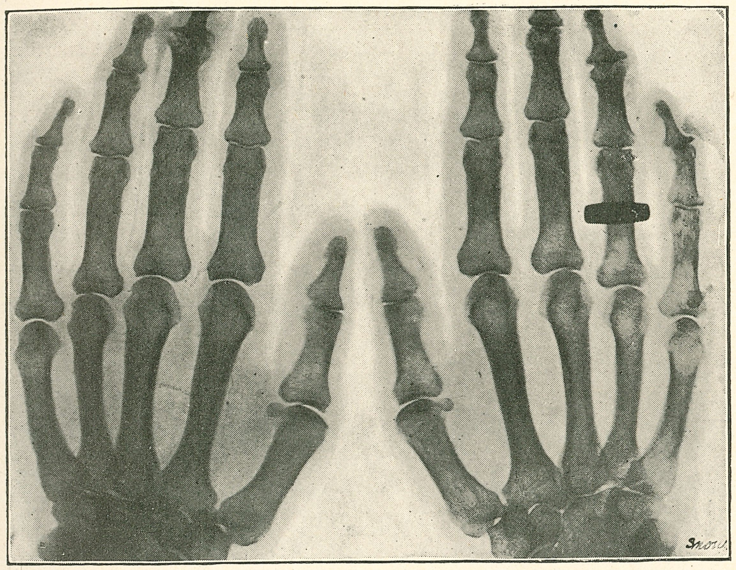


Fig. 42.

results, and should be administered in frequency according to the indications.

The fourth type of arthritis deformans, of which a skiagraph is shown in Fig. 44, has an unique characteristic in that only a single finger of each hand is similarly affected, it being the corresponding finger on both. This case was in an otherwise healthy patient, an artist by profession, with no history of any other joint affection. The fingers were curved as by equal contraction of the muscles, anteriorly and posteriorly, the fingers at the end phalanx being turned towards the thumb and at the middle joint in the opposite direction. The patient recovered under the treatment given for rheumatoid arthritis with the finger only partially movable, and in an extended

position—not flexed. The writer has seen no description of a similar case, and it cannot be classified with either of the other types of arthritis deformans.

Spondylitis deformans is a rare affection which, to the present time, has received no relief from the surgeon or physician. It belongs properly in the same class with rheumatoid

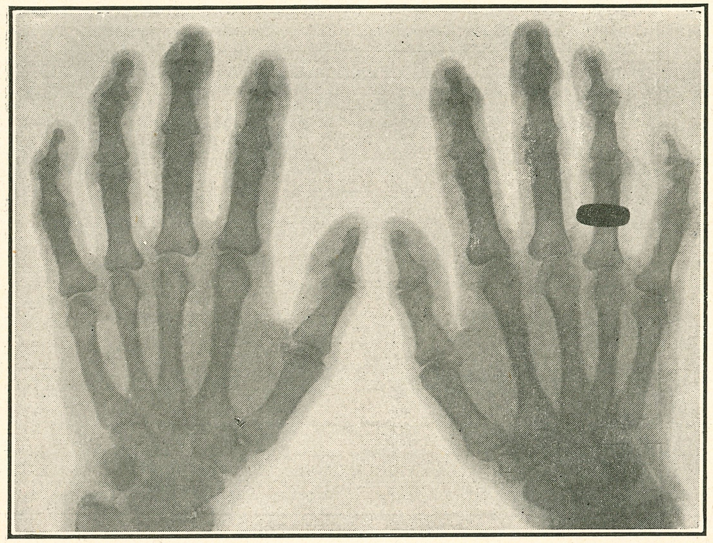


Fig. 43.

arthritis, and is characterized by destruction of the inter-articular vertebral cartilages. The disease is probably due to causes similar to those which induce rheumatoid arthritis. It may or may not be associated with a rheumatic history, and the course of the disease is always to progress from bad to worse. The deformity is characteristic, the back being gradually curved forward as the cartilages become thinner.

No case of this affection, so far as the writer can ascertain, has ever recovered. The plan of treating rheumatoid arthritis and the success with other spinal affections caused the writer to advise in these cases the trial of the static wave-current and sparks to the spine. This should be done in conjunction with a

plaster jacket beneath which the electrodes may be readily placed. The current should be administered daily for two or three weeks, employing an electrode two inches wide by eight or ten inches long, placing it first from above downward and giving as long a spark-gap as the patient will permit without

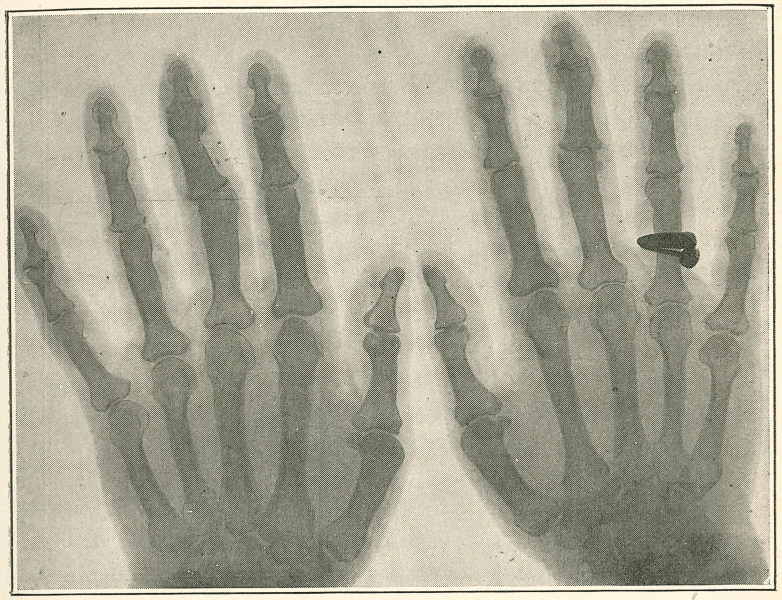


Fig. 44.

discomfort from the muscular contractions or pain over an inflammatory area which will usually be from five to seven inches in length; then place it from below upward, employing the same rule as to length of spark-gap. These administrations should be for fifteen minutes each, at the close of which a few long sparks may be administered parallel with and near the spinous processes. This treatment should be kept up daily for the first two or three weeks and upon alternate days for a long period—until the active process seems to be stayed and the patient, if possible, is able to get along without the plaster jacket.

The success that will attend this procedure is so far an open question. The writer, however, is observing the treatment with excellent prospects of benefit. As there are no contraindications and the procedure promises much, there can be no mistake to endeavor to spare these sufferers by the methods suggested.

SYNOVITIS.

This affection, when not characterized by the presence of pus, should be treated in the same manner as the other forms of arthritis, employing the wave-current, sparks, and the brush-discharge. The results are uniformly successful, the time necessary to complete the cure depending upon (1) the length of time since its appearance, (2) the general health of the patient, (3) the presence of dense layers of fat over the joint. In the latter very long percussion sparks will be imperative, and much time will be necessary to effect a cure, because the vibratory action of the electro-static currents, or sparks, cannot be brought so effectively to act upon the muscular, circulatory, and lymphatic structures through a thick, almost non-conducting cushion of fat.

Many other affections might be included in this chapter,—as neuritis, coccygodynia, and myelitis,—but it is thought best to include them with other special classifications. The fifth class, including nephritis, tonsilitis, and those conditions arising from functional inactivities and unknown causes, will be considered in a chapter on Miscellaneous Diseases.

CHAPTER XII.

THE PAINFUL NEUROSES.

Diseases of the nervous system characterized by pain may be due to (1) inflammatory conditions, as neuritis, or (2) arise from affections of the central nervous system, as tabes, or (3) as a symptom of malnutrition, or chronic poisoning, occurring with various cachexias, or (4) from reflex causes and from depleted conditions, as neuralgia.

Most of these painful neuroses can be relieved, and the larger part of them cured, by static applications, when they have not become too chronic, or if some internal organic lesion is not present to preclude the possibility. The greatest obstacle to successful treatment with these, as with other cases, is the presence of a thick layer of fat between the surface and the seat of the trouble. Deeply seated affections, as neuritis of the sacral plexus, or in a bony canal, as of the chronic cases of tic douloureux and cases of neuritis in regions where muscles are sensitive and contract under strong administrations of the wave-current, as of the branches of the brachial plexus in the arm and forearm, require special methods of application, *q. v.* Pathological conditions which interfere materially are the forms of sarcoma and carcinoma, now in many cases satisfactorily relieved by the X-ray; tubercular disease of the bone or lymphatic glands, and various tumors pressing upon deep structures.

NEURITIS.

The various types, as the name implies, arise from exposures when, from fatigue or a lowered state, the reactions are below the standard; from strains or traumatisms, or from complicating inflammatory conditions, as rheumatism, rheumatoid arthritis, or Pott's disease of the spine.

Any nerve may become the site of neuritis. It occurs most

commonly in the sciatic nerve, the branches of the brachial plexus, and the facial nerve. Neuritis is the condition present in many so-called neuralgias.

SCIATICA.

Neuritis of the sciatic is perhaps the most common and intractable of the forms of neuritis, when treated by methods other than the static. The localities most commonly the seat of the inflammatory process are at the sacro-sciatic notch where the nerve emerges from the pelvis, and the pain most marked is in the branches distributed to the foot. Quite often cases are met where it is difficult at first to determine the location of the lesion. In these it will generally be located in the sacral plexus, or in the region of the cord, when the prognosis may be in doubt from the various pelvic conditions that may complicate the case.

The diagnosis of the site or extent of the sciatica, or of any neuritis except within the cavities of the body or bony canals of the head, is easily made by applying sparks, the brush-discharge, or the high-frequency discharges employing the glass-vacuum electrodes along the course of the nerve, noting the points at which the severe pain begins and ends, and at the same time comparing the effect at corresponding points of the opposite side of the body. A spark over a nerve, especially at the motor points, is always painful, but when applied over the part of the nerve that is the seat of the neuritis, the pain is intense. When determining the extent of the neuritis, it is only necessary to watch the facial expression of the patient during the application to mark the limits of the inflammation, as we map it out with the sparks.

The *prognosis* of uncomplicated neuritis, when accessible, is very satisfactory.

The treatment will vary with the conditions of the case. In acute recent cases, when the patient is muscular and not too fat, the wave-current is all that will be required to effect a complete cure in a few days; the more recent the case the shorter the time needed, other things being equal. In fat patients, and chronic cases, it will be necessary to make use of long sparks to obtain the desired result. Over the foot and leg, prolonged applications of the brush-discharge will give satisfactory results. Over the affected region, when it has been located, place an electrode of soft metal and see that it is firmly held to the surface and administer the wave-current. When employing the wave-current, or one of the modified currents, select an electrode with reference to the capacity of the machine or current used, the extent of the lesion, and the tissues of the patient. It is an intense vibratory effect that is required, to which the affected nerve must be sensitive when but a small part of the possible current strength is employed. It may then be gradually increased until the sedation is complete, which will be determined by lengthening the spark-gap without increasing pain. The electrode should rarely be larger than 4 x 4 inches.

At the beginning of the administration of any static current, the electrode having been secured so that it will be firmly pressed to the affected spot, open the spark-gap to a point at which the patient cannot, without much discomfort, take any more. As the sensation becomes less severe gradually lengthen the spark-gap, when, at the end of at least fifteen or twenty minutes, the sedation will in most cases be complete. If the result be satisfactory, there will often be little or no pain whatever for twenty-four hours. In such, a daily administration will effect a cure in a short time. In others, the pain may return sooner, and require, for a few days, morning and evening treatments, after which the periods may be gradually lengthened. In other cases, especially those of three or more weeks' standing, the wave-current will fail to produce the complete sedation required; in such, long sparks should be applied directly to the affected nerve over the whole extent of the lesion, and they will, as a rule, accomplish the desired result. Test the effect by having the patient exercise the muscles in the vicinity of the affected nerve, by stepping off and on the platform, standing with the weight upon the affected leg, and by moving the body in various positions. If it is found that the sparks are giving relief, persevere until it is complete. Others say that they have known cases to be aggra-

vated by the sparks. The writer, however, in records of more than one hundred cases has found none but what sparks would partially relieve, and not one was aggravated. The brush-discharge, or prolonged administration of the spray, may assist in relieving some who are not too fat, or cases that are not too chronic. The latter invariably require sparks. *Bridging* is of the utmost importance, and, when properly observed, we are satisfied that every uncomplicated case of sciatica can be cured by one or another of the electro-static modalities.

Neuritis within the pelvis occurs so often as a complication of other conditions, due to pressure or inflammatory processes in that region, that it is important to exclude a possible Pott's disease, carcinoma, or other tumor before undertaking the case, and certainly before giving any but a most guarded prognosis. That these conditions may be satisfactorily treated, when uncomplicated, the writer's experience has led him to believe.

Some cases which the writer has treated have been successfully managed by the use of the wave-current. When the lesion is in the lumbar plexus, it will be discovered by the effect of the intense vibratory action of a powerful current (4- to 6-inch spark-gap) applied at the back over that region, producing a painful sensation along the course of distribution of branches of the obturator and crural nerves. Place a soft metal electrode (22 gauge) directly over the affected region and connect the patient for the administration of the wave-current. Make the spark-gap as long as is possible in each case without causing severe pain or muscular contraction of the structures in the vicinity of the affected area of congestion. Then place the point electrode upon the standard at a point directly opposite the electrode in front of the patient, at a distance which will not interfere with a regular discharge of the spark-gap. By this means the affected region is placed in a vibratory field of greater intensity. If the length of the spark-gap has been limited by the local pain caused by the action of the current, it may be lengthened from time to time, as in other cases until sedation is complete.

This may require from twenty minutes to half an hour.

The vibrations over the lesion, and the coincident induced interrupted muscular contraction of the arterioles and muscular structures in the vicinity of the congestion, relieve the congestion and hasten the cure of the patient. The observance of *bridging*—regulating the indicated frequency of administration —must be adhered to, as in the treatment of all conditions. The same general plan applies to cord affections or neuritis of the sacral plexus.

Brachial neuritis differs in no essential characteristic from the conditions which have just been considered, and the principles of treatment are the same. In the branches which supply the arm and forearm it is impossible to employ a spark-gap of more than an inch or two, because the muscles are thrown into a state of painful contraction. Nor is it necessary, for the same reason. Sparks give great relief in many cases and may be administered directly over the inflamed and painful portion of the nerve. The great relief which follows these severe applications encourages the most timid patients to endure them. During the course of the application of sparks or the convective discharges, the patient should move the arm about, making all movements that had caused pain; at the same time indicating the painful spots and those to which sparks give relief. Let the operator bear in mind that the motor points and bony prominences are always painful to sparks, and that to the latter they do no good, and to the former only when the nerve at that point is the seat of neuritis, and much needless suffering from a superfluity of sparks will be spared the patient.

With patients who do not bear sparks well and in acute cases, it may be possible to cure those in whom the nerve is not covered with thick muscles of fat, by using the brush-discharge or the spray following the wave-current during each administration, until the pain ceases. When pain on movement is thus relieved it is always fair to suppose, in any inflammatory condition, that the congestion is lessened; but experience with each case, noting the length of duration of the cessation of pain, will be a guide to the degree of effect upon the inflammation. If the relief is for but one or two hours, the next administration

should be continued until a marked rubefacient effect is produced over a considerable area; failing in this, induce the patient to submit to sparks, which will succeed. The rubefacient action of the brush-discharge is valuable in all cases of brachial neuritis, when the necessary time to produce it can be spared.

It should be borne in mind in all cases, when treating regions of congestion, that muscular contraction of the coats of the vessels and the muscles surrounding them induces normal circulation and overcomes stasis by forcing onward the blood stream. As pressure thus exerted relieves the more superficial congestion, the pain caused by a current measured by the spark-gap employed at the time ceases, while upon lengthening the spark-gap the effect which is deeper causes a return of pain each time and is repeated until the local congestion is relieved. At this stage of the treatment sedation of pain from relief of the inflammatory conditions at the time of the first administration may not be complete, but it will be effected in curable cases within the first days of treatment.

Great relief may be given in these cases and recovery hastened by the employment of the brush-discharge or high-frequency administered with glass vacuum electrodes. Acute cases may even be cured by the last-mentioned modalities. In all chronic cases of neuritis sparks will be found indispensable, and in brachial neuritis should be employed from one and one-half to three inches in length.

Neuritis in various other regions requires the same general plan of treatment as in the preceding special cases. **Facial neuritis** will be considered with the neuralgias, because it is generally so classified.

LOCOMOTOR ATAXIA.

Tabes is characterized by a degeneration of the central and peripheral sensory nervous system.

The ætiology is obscure, no certain cause being traceable in most of the cases. The fact that many patients present a syphilitic history has induced some writers to consider it the specific cause. Such observers, however, are largely in the minority. The position is taken by Gowers "that there is nothing in the histological character of the lesion that can be compared with the morbid processes that are certainly syphilitic." "There is nothing, therefore, to warrant the opinion that any morbid germs existing in the cord or nerves lead to the development of the disease." "It is probable that syphilis leaves behind it a predisposition to nerve degeneration, lowers in certain nerve elements the capacity for resisting morbid influences, leaves many patients in a condition analogous to one who inherits a predisposition to neural disease." Much diversity of opinion exists as to the percentage in which a syphilitic history *can* be traced. Some place it as low as forty per cent. and others as high as seventy-five per cent. It evidently does create a predisposition, but is not the cause *ipso facto*. The same conditions which may be attributed to syphilis are produced by other exhausting and enervating causes, as accidents (particularly concussion of the spine), exposure to cold, fatigue, exhausting diseases, excess of venery, and many others.

The pathology of the disease is characteristic. Cerebral centers are but slightly affected, while the centers in the cord, generally most marked in the lumbar region, are largely the seat of the trouble.

Evidences of inflammatory processes, so generally absent in congested conditions after death, are indicated by changes in the blood vessels (thickening of their walls) and overgrowth of the neuroglia which lies between and supports the ganglionic cells. The primary changes seem to take place in the ganglionic cells, which become atrophied or disappear, to be replaced by connective tissue. It is most probable that the lesion is of a congestive or inflammatory nature associated with a lowered constitutional state and marked by varying degrees of activity, the results of which are to be found only after death (pressure destroying and impairing the functional activity of the cells), but of a type favorable to the growth of connective tissue.

The symptoms, briefly considered, that are characteristic, are (1) the pains; which vary from mild pains, apt in the first stage

to be mistaken for neuralgia, to the severe boring and lancinating pains, (2) the ataxic walk, (3) girdle sensations, (4) Argyll-Robertson pupil, (5) areas of anæsthesia, (6) abolished reflexes, (7) impaired function of the rectal, vesical, and sexual apparatus, (8) and joint and tissue degeneration. Several of these symptoms are more or less constant in every case, and most of them occur at one time or another with sufferers in whom the disease runs an uninterrupted course. In no disease are the symptoms so variable and unaccountable as in *tabes dorsalis*.

The prognosis is variable; depending upon the stage of the disease, the severity of the lesion, the physical condition of the patient, and the character and frequency of the treatments. We believe that, in patients not afflicted with other organic disease, it can be stayed in its progress and many of the symptoms be decidedly relieved, and that in the first stages it can generally be cured; only conditions referable to irreparable or destroyed cells remaining.

Treatment of locomotor ataxia must meet at least three indications—the improvement of the general status, the arrest of the processes, and the relief of symptoms.

(1) If degeneration is the primitive condition, and the cause not a specific organism, but a lowered vital state, especially of the nervous system, the indication for treatment is the employment of means of restoration or regeneration.

(2) The inflammatory processes which are undoubtedly present and productive of destruction or atrophy of the ganglion cells, either by the pressure exerted by congested tissue, or by the action of the inflammatory process attacking the cell protoplasm itself, must be interrupted if the local lesion is to be arrested.

(3) The treatment which arrests the lesion will relieve the symptoms to some extent, and the electrical treatment, when applied to the symptoms in the manner to be described, creates by "ingoing impression," as taught by Morton, a return, at least partial, to activity of many centers, even during the administration.

Electrical treatment has for a long time been recognized by medical electrologists to possess merit in the treatment of tabes, but neurologists generally prescribe it only as they do the iodides. The fact is that favorable results can only be obtained from electrical treatment with a devotion to technique, which must be directed to the conditions, and time devoted to each administration sufficient to obtain the desired effect, and a frequency of administration which will bridge over the gains. Observing these measures, *electro-static* treatment, at least, will meet many indications, and generally prove satisfactory to both physician and patient.

Ganglion cells that have been destroyed cannot be replaced or regenerated in any case. The patient must, therefore, be made to understand that restoration, other things being equal, will be relative to the number of cells destroyed, and the condition and surroundings of the cells impaired, which are unknown.

The first indication is met with possibly the judicious use of tonics and attention to diet, together with twenty to thirty minutes' administration of the wave-current. The effects of tonic static administrations upon all nutritional derangements are energizing and restorative; evidenced, as has been shown in the preceding chapters, by improvement in appetite, nutrition, and activity of every body function. Such are the effects in all cases with locomotor-ataxia patients not affected with other organic disease. No special administration of the wave-current will be necessary when the local use is for a long enough period of time, and employing sufficient voltage, to insure the required effect.

The second indication to be met—the relief of the inflammatory characteristics of the lesion—is not only demonstrated to be relieved, but the fact that such lesion exists, if other evidence was not adducible, is also demonstrated; or else some other reasonable theory must be presented for the restoration of the functions, which does take place in so many patients that the results seem to be confirmatory.

The removal of the pressure from the ganglion cells, by the withdrawal of the congestion, permits a general restoration of their function, to a greater or less degree; while a theory of

regeneration, or the substitution of new ganglion cells, would be contrary to fact. When it is so certainly a fact that congestion is removed from the deep structures of a knee or hip joint by static administration, it is not presumption to expect that the same thing will take place within the spinal cord. Certainly, no other fact will explain the relief afforded cases of anterior polio-myelitis as reported in a subsequent chapter.

For relief of the cord affection, place over the region or regions affected a soft metal (22 gauge) electrode two inches wide, and secure it firmly by placing a pillow against the patient's back; connect with the positive pole of the static machine, and administer the wave-current, employing a spark-gap of four to six inches in length for at least fifteen minutes. Follow this with the same administration of short sparks to the soles of the feet.

For this purpose the writer has adopted the following plan: Place upon a metal plate in front of the patient a piece of felt or several thicknesses of woolen cloth upon which the patient, having removed his shoes, should place his feet. Place the shepherd's crook from the metal plate to the positive side of the machine. The spark-gap having been closed, separate it again gradually until it begins to produce a disagreeable sensation to the patient. Continue this administration for ten minutes. This procedure assists materially in relieving the anæsthesia in the soles of the feet. Follow this application with a general administration of friction sparks to all anæsthetic and painful areas on the body of the patient. Make these applications rapidly over the surface until the effect, at first mild, becomes disagreeable to the patient. (The fact that during a prolonged course of treatment these areas do become more sensitive is to the writer inevitable proof that the corresponding centers in the cord have been released or made active.) Long sparks liberally applied over the region of the cord are indicated in all cases, especially so in plethoric individuals, for insuring relief to the congested conditions of the cord.

The third indication, the symptomatic, is of great importance, and contributes no small amount to the relief of the central lesion and the awakening of the liberated, but dormant, cells.

Pain, the most interesting symptom of tabes, yields satisfactorily in almost every case to one or another of the modalities. Patients who were taking many grains of morphine daily for relief have, to the writer's knowledge, been able to abandon the drug altogether after a few weeks' treatment. The wave-current, sparks, and brush-discharge have each given temporary relief when locally applied. The greatest measure of relief from this symptom, as from all others, is derived from the general and direct spinal application.

The Argyll-Robertson pupil and other optic symptoms, when once present, have never been benefited by treatment in the writer's experience, nor in cases in records examined.

The ataxic walk is caused by the anæsthesia and diminished sense of co-ordination, and is improved, as a rule, in proportion to the restoration of sensation.

The abolished reflexes are rarely, if ever, restored by any treatment.

The impaired vesical, rectal, and sexual functions may each be greatly benefited by the stimulating effects of the wave-current locally applied, and friction sparks above the pubes, and to the penis and perineum.

To the tissue and joint degeneration we would administer the brush-discharge. When assuming charge of a case of locomotor ataxia the serious nature of the affection should be explained to the patient, and he should be instructed that no definite prognosis can be given as to the length of time the treatment must be continued. It will vary with the severity of the symptoms, the general health, environments, and habits of the patient. No case should be undertaken with an expectation of satisfactory results within one year. And so long as pain persists the lesion may be considered to be active. The patient should also be enjoined to abstain from all excesses, especially of alcohol and venery. Under systematic regimen and the thorough and scientific employment of Franklinism the majority of cases of locomotor ataxia will be considerably relieved and the progress of the disease will be brought to a *status quo.*

NEURALGIA.

Neuralgia is another name for pain and has long been recognized as a misleading and unscientific term—classing a symptom as a disease. It is not correct to permit such professional license because an obscure or remote condition is difficult to diagnose. It would be better to admit ignorance, and, when possible, find out the cause.

When a local pain is persistent, a local cause may be presumed to be present; in a few cases, however, the lesion will be found in the central nervous system, or at an injured point in the course of the nerve.

The pains associated with adynamic conditions, such as the cachexias, anæmia, and chronic malarial poisoning, are never constant, but flitting, and demand the indicated constitutional treatment.

Reflex pains also are not constant, but vary with the condition of the organ from which they originate.

The treatment of neuralgia should not, on general principles, be instituted when it is possible to locate a lesion until a diagnosis has been made. When, however, it is possible to locate a cause the local application of Franklinism will often relieve the pain. In other cases an application will become an aid to diagnosis by exclusion—a condition not yielding will, as a rule, be due to an organic lesion, local or central.

For the relief of pain all of the static modalities possess merit. We place them, from our own experience, in the following order of preference, viz., wave-current, brush-discharge, high-frequency applications, sparks, breeze, spray, static insulation (nutritional), and the static-induced current. The first five meet all demands, and will be treated according to special indications in the following pages.

Coccygodynia is due in most cases to either an arthritis or neuritis; both generally intractable to all but electrical treatment. The constant and induced currents have achieved small success in this painful affection, and electricity has therefore been rated a failure by many. The old currents are impotent because they do not relieve the local congestion which

is always present in an arthritis or neuritis. It has been demonstrated that the static modalities are successful in every case which has continued the treatment, when the products of inflammation had not formed deposits which restricted motion. The prognosis is generally good, and the time necessary to effect a cure will depend upon the chronicity and extent of the injury.

The wave-current will give satisfactory results when applied by adapting a tin electrode to the region, and after securing it, employing the current in the manner in which we treat neuritis for fifteen to twenty minutes. If a trace of pain remains, it may be relieved, in most cases, with either the brush-discharge or sparks; the former being indicated in acute cases associated with tenderness and possible ecchymosis resulting from an injury; and the latter in chronic cases, to promote the reabsorption of the products of inflammation.

Intercostal neuralgia (generally neuritis), when not due to pressure other than congestion, will be promptly cured by the same processes described in the preceding affection.

Facial neuralgia, of the trigeminus, is a common and often stubborn affection. The exposure to which the face is subjected and the fact that many branches of the nerve in this region pass through bony canals or across bony prominences make it prone to injury. When slight pressure, from congestion of either the neurilemma or the structures surrounding the nerve, or from small tumors or exostoses, is present, pain of a more or less permanent character results. One writer says that "neuralgia of the trifacial is the most frequent form, when the disease is due to malaria." So often is the condition due to a congestive hyperæmia that the early treatment of tic douloureux by the wave-current, brush-discharge, or sparks, acts as a prompt cure in most cases, and these methods promise very much in cases of longer standing. When a tumor, an exostosis, or aneurism is the cause, temporary relief may be afforded, but nothing more should be expected. So, when due to malaria, much relief may result from treatment; but the question of first importance is the treatment of the malaria.

The diagnosis of the cause of facial neuralgia is not always easy, or the term neuralgia would not be so often employed.

The prognosis must be guarded in all but the recent cases, which yield promptly when due to local congestion not caused by abscess or bone necrosis.

The treatment by exposure to the Roentgen ray, if caused by epithelioma, offers great encouragement. (See chapters on Radiotherapy.)

The application of the wave-current to a violent case of tic douloureux was the first revelation to the writer of its remarkable anodyne effects, which are now recognized by many electro-therapeutists in this country. When employing the wave-current, select an electrode which will cover the face on the affected side, requesting the patient to hold it in position with the ball of the thumb; pressing it firmly to the affected or painful spot, connect by a rheophore, and start the machine, employing a very short spark-gap; opening it until the pain begins to be severe. At this juncture, in acute cases, many of the motor points of the face in distribution of the nerve become painful. If so, the patient should press the tin firmly with the fingers to such spots. The administration should be continued for twenty minutes, during which time the operator should gradually lengthen the spark-gap. Care should be taken that this be done in the most cautious and delicate manner, as a sudden shock will be very painful and greatly disturb any patient. By gently withdrawing the rod with a screwing movement, at the same time consulting the sensations of the patient, it may be easily accomplished without casualty.

The brush-discharge will give very great satisfaction in facial neuralgia. It should be applied over a surface considerably larger than the painful area (unless the whole face is involved, when the entire surface should be treated) until a distinctly rubefacient effect is produced.

Short sparks may be found of service in some chronic cases, but as a rule avail little when the other modalities fail. Strict attention to *bridging* will insure the best results. Acute cases will often require two administrations daily during the first days of treatment.

Podalgia and plantar neuralgia deserve attention here, because in most cases the static modalities give prompt relief.

Podalgia (painful heel) is a condition which may be associated with flat-foot, rheumatism, gout, or neuritis, and is especially liable to occur in persons who are much on their feet. The extent of the affection will vary from a small circumscribed spot to the whole surface of the heel. A few will prove intractable, even to the electro-static treatment. Such will usually be associated with flat-foot, which in early cases is not sufficiently marked to be detected.

The usual means for treating painful affections have merit in most of these cases, and should be employed heroically, if the case demands it. The best results have been obtained by the writer from the application of sparks, applied directly to the painful spot.

Plantar neuralgia is apt to occur, says Osler, after "cold-bath treatment of typhoid fever." It also occurs as neuritis or with gout or rheumatism, and is satisfactorily treated by the wave-current and brush-discharge. In this affection sparks are rarely necessary.

Gastralgia, cardialgia, nephralgia, also neuralgia of the liver, rectum, ovary, and testicles, occur with neuropathic conditions, and are often associated with cachectic and other lowered constitutional states. All call for both constitutional and local treatment. There is probably no one agency that accomplishes more for these painful conditions than Franklinism. At the same time, far be it from us to disparage the use of other tonics or safe alteratives which, associated with proper diet and good hygiene, will hasten recovery.

The tonic effects of the wave-current work wonders in these conditions and cannot be too strongly advised. It matters little where the electrode is applied to produce the energizing effects. Experience with very many cases, which were uniformly improved in general health while receiving local treatment and no medication, both to the body and the extremities, has impressed the writer that with patients in whom there is a

lowered condition of health, without organic disease, they are coincidently restored. On general principles, apply an electrode to the spine or over the epigastrium for tonic effects. It is not considered necessary, however, with administrations aggregating from twenty minutes to half an hour, with a wave-current measured by at least a four-inch spark-gap, wherever applied, to make other applications for the purpose of improving nutrition. Therefore, when called upon to treat these neuralgias, apply an electrode having a surface of sixteen to twenty square inches directly over the painful surface, and continue the administration for at least twenty minutes, and the local and constitutional treatment will both have been accomplished. Daily administrations should be given for at least two weeks, and continued later every second day until health is restored.

Gastralgia is cut short during the attack in most instances, and when the treatments are continued for a sufficient period, generally ceases to recur altogether unless some persisting cause be present.

Cardialgia, induced by a poorly nourished or overworked heart, is greatly relieved by the local administration, and after a period of treatment often cured and the patient restored to a normal condition of health.

For **angina pectoris** we believe no treatment promises so much,—if atheroma of the coronary artery is not in an advanced condition,—because it lowers arterial tension, promotes the elimination of mineral salts, and preserves a constitutional equilibrium. In the treatment of false angina, occurring in neurasthenic and hysterical individuals, it is successful, as it is also in removing the associated affections.

In treating these conditions, apply an electrode about four inches square over the præcordial region, and treat the primary affection according to indications.

For relief of neuralgia of the liver or kidneys, apply the electrode and continue the administration for at least twenty minutes.

Ovarian neuralgia requires tonic treatment, as well as relief of local pelvic congestion so often associated with the condition

to which, when present, the pain is secondary. Apply the wave-current over the painful spot, employing a large electrode when weather conditions are favorable to the use of a long spark-gap; continuing for fifteen or twenty minutes. Another method, often successful, is to employ a large vaginal electrode connected to one side of the machine, and the abdominal electrode connected to the other side, employing the static-induced current, or the wave-current with a rectal electrode in the vagina or rectum. (See Dysmenorrhea.)

The brush-discharge, applied over a considerable area until a rubefacient effect is produced, will give marked relief, and, when applied daily over the lower abdominal region, will have a pronounced effect in lessening or removing pelvic congestion.

Neuralgia of the rectum should be treated by placing a large special electrode in the rectum and employing the wave-current. If the case is not due to structural changes or foreign bodies, the result will be satisfactory.

Neuralgia of the testicle is best treated by application of the brush-discharge for from fifteen to twenty minutes. Few painful or congested conditions of the testicle will not yield to this modality. Great care should be taken that during the administrations accidental sparks do not pass to the testicle or the penis. (See Administration of Brush-Discharge.) Sparks are not harmful, but are so painful that a timid patient might be greatly annoyed.

MIGRAINE.

This superficial or deep-seated pain is usually confined to the temporal or orbital region of one side of the head, and in most cases is associated with nausea. Heredity, neuropathic and adynamic conditions predispose to the attacks; and, in proportion as such influences can be checked, allayed, or normal condition restored, can these sufferers be relieved. As in all nervous diseases of hereditary origin, those cases in particular are most intractable, and must be taken carefully in hand from the first appearance in childhood. The *indications* must be di-

rected (1) to improving the general nutrition; (2) to lessening the nervous irritability by restoring, or establishing, a proper stability of the nervous system; (3) to correcting or removing exciting causes as far as possible which induce attacks; and, (4) to relieving the attacks when they do occur.

The first two and last of the indications are perhaps better met by static electricity than any other plan of treatment, while the third will call for attention to various physical derangements—as eye strain, nasal affections, uterine disorders, gastro-intestinal derangements, and overwork or worry.

What has been already said of the nutritional effects of Franklinism applies here, as in all other conditions. That which induces general functional activity restores an equilibrium, and takes the strain from the overworked parts and sets the sluggish organs to their task, unless a physical disability (as an organic lesion) is present, and thereby does much to lessen nervous irritability. High-potential electricity, however, does more than this to an overstrained and irritated nervous system. It quiets, soothes, and rests exhausted nerves, producing a sense of well-being, repose, and refreshing sleep.

The prognosis will vary with many conditions.

When treating for this affection, no specified time that it will take to effect the desired result can be promised. It will always depend upon the peculiarities and progress of the individual case. It will take months, and, in neuropathic individuals, a longer time, and in a few it may be necessary to keep up treatment indefinitely to maintain an improved status that has been established; and in still other rare cases, especially with otherwise healthy individuals, the treatment will neither influence the frequency nor the severity of the attacks.

The treatment during the intervals between the attacks should consist of administrations daily, or upon alternate days, of the wave-current for from twenty minutes to one-half hour at each time. Apply an electrode, having a surface area of from sixteen to twenty-four inches, to any portion of the trunk of the body where there may be indications for local treatment, over the upper or lower abdominal or lumbar region; or a long spinal electrode over the vertebral column. Adapt the

spark-gap to the physical conditions of the patient. During an attack observe the same rule of applying the electrode, and at the same time place the point of the stand electrode over the patient's head, at a distance at which it will not interrupt the spark-gap. In some patients the breeze, thus applied to the head, seems to aggravate the pain; with such, the point placed in front of the knees, at the same distance as before, will, as a rule, have the desired effect. The polarity affects patients differently. We generally employ the positive insulation, adapting it to the idiosyncrasy of the patient. The noise of the discharging spark-gap will aggravate some of the patients; then the balls must be widely separated. The brush-discharge, applied to the aching head, will afford great relief in very many cases, while to a few it will prove an aggravation.

If care is taken to discover the idiosyncrasies of patients and regulation of dosage, few indeed will not be relieved.

The same general principles apply to the treatment of other headaches as to migraine; and care should be taken to remove the cause, when possible.

CHAPTER XIII.

GENERAL TREATMENT OF PARALYSIS.

PARALYSIS is "a loss or diminution of the powers of contractility in the voluntary or involuntary muscles, or of perceiving sensations."

Such a condition, occurring in a large or small portion of the body, may be induced by injury, degeneration, or pressure exerted upon the corresponding centers in the brain, the spinal cord, or in the course of the nerve between the centers and its peripheral distribution. The two former are termed central, and the latter peripheral, paralysis.

The degree of recovery will depend upon (1) the promptness with which the cause, if a central lesion, is removed; (2) the maintenance of the nutrition of the parts paralyzed in the interval between the onset and the recovery, if possible, of the normal function, and (3) the employment of physical or medical measures which facilitate the removal of the cause or the maintenance of nutrition, or both.

The continuance of pressure upon ganglion cells, whether from a clot, congestion, or gumma, causes their destruction within a brief period of time. Likewise, cells cut off from nutrition by obstruction of the blood channels, by thrombosis, or embolism, soon degenerate. Ganglion cells, once destroyed, are never restored, nor the function of the parts of the corresponding nerve distribution.

The *prognosis* of a given case of paralysis, then, will depend upon so many unknown conditions that, in most cases of central origin, it should be very guarded. In peripheral paralysis, however, the prognosis is generally favorable.

Paralysis caused by brain lesions will be associated with a very small degree of atrophy, from which the cases due to lesions of the cord show a decided contrast. The marked atrophy in the latter is undoubtedly due to the involvement

of the trophic centers which influence nutrition, while in the former, and in peripheral paralysis, only the atrophy of disuse will occur. Peripheral paralysis will, in most cases, be recognized by the history, peculiar features, and generally prompt recovery. In some, however, it will be difficult to locate the lesion.

The general *indications* for treatment are, (1) if possible, to remove the cause, (2) to preserve the local nutrition of the parts paralyzed, and (3) to preserve the patient's general health and nutrition.

The causes, for the purposes of consideration, will be classified as (1) obstructive, (2) traumatic, (3) congestive, and (4) specific.

The *treatment* in many instances will combine with the electrical administration, medical or surgical measures, to which it is only possible to allude in the most general way, for, while such measures are often invaluable, it would not be practicable to treat them to any extent in a work on electro-therapeutics.

The remedy for removal of obstruction or pressure due to pathological conditions (which amounts to the same thing) is one which will assist or promote reabsorption, or the establishment of the collateral circulation to supply the parts cut off. In this line very little can be accomplished—nature's provisions alone can bring about the restoration. Strychnine, to quicken the activities, and tonics and nutritious diet do much. But when possible for the patient to receive the tonic static administrations, which increase secretion, promote absorption, improve general nutrition, and relieve arterial tension, their value is certainly apparent.

Traumatic cases, when associated with depressed fragments or portions of bone, or a disarticulation or fracture of the vertebral column, first demand surgical measures. Later these cases, as well as those of concussion, in which congestion, active or passive, from the very nature of things must result, call for the same active local treatment as congestions generally, the consideration of which follows.

The congestive lesions of the brain or spinal cord are the most common causes of paralysis, being largely the factor in

all cases due to mechanical obstruction, and therefore we look for the greatest measure of success from electro-static administrations in the earliest stage of the affection. When making this statement it is with a full realization that it is in direct opposition to the long-established dictum of neurologists and electrologists. In defense of this departure it can be explained that when electricity has been employed in paralysis, until possibly within the past few years, it has been either the constant or the interrupted (faradic) current. To the former can be attributed injurious effects due to electro-chemical action, and the latter was so deficient in electro-motive force that no effect whatever was made upon the inflammatory conditions within the spinal canal. Now that it can be demonstrated that either the vibratory or electrical effects of currents of great potential, or the combined effects of both, do materially and efficiently lessen deep local congestion, what contra-indication can be presented against their employment in inflammatory cord or brain affections? If a deep knee or hip-joint affection of such character can be relieved, so can a congestion within the spinal canal. Such was the writer's premise more than four years ago; and experience with an ample number of cases of his own, and by his advice in the cases of other physicians, has proved that the theory was correct.

Anterior Poliomyelitis.—The *modus operandi* of the treatment of two typical cases of anterior poliomyelitis follows: The first case was reported by the writer in a paper read before the Post-Graduate Clinical Society of the New York Post-Graduate Medical School, entitled "The Electro-Static Treatment of Some Forms of Paralysis." A child thirteen months of age, after six weeks' treatment in the clinic of an able neurologist in New York, was referred to the writer in the following condition: "Complete paralysis of both lower limbs, except power to move the toes on one foot, and the reaction of degeneration well marked. When the child was brought to the office on the morning after the first administration, he could move the feet at the ankle joints, and on each subsequent day there was additional power of motion, and after six treatments he could move ankle, knee, and hip joints with ease and considerable force. The case then disappeared; the mother, a Polish Jewess, thinking the child cured." The other case was referred by Dr. A. H. Allan of Gouverneur, N. Y.; and the doctor's report of the case is herewith given from a communication received about one year later:

"F. F., a boy aged fifteen, previously healthy, was taken in the night of March 3, 1900, with fever, vomiting, and pains in the back and legs. On trying to get up in the morning he was unable to walk. During the next forty-eight hours he became entirely paralyzed, except his right shoulder muscles, which did not become involved. The paralysis also extended to the right side of his face. He was completely helpless. I prescribed the usual remedies, but there was no improvement in his condition.

"A few days after this business called me to New York, and I consulted Dr. Wm. Benham Snow in regard to the case. He advised me to begin treatment at once with static electricity, and instructed me in the method of using the current for this particular case. On my return, two weeks after the boy was attacked, I found there had been no improvement. The muscles of his limbs were very flaccid, and atrophy was well marked. March 18 I had the boy well wrapped in blankets and brought to my office, and began the electrical treatment, as instructed by Dr. Snow, which consisted of the Morton wave-current to his spine and frictional and indirect sparks to the whole surface of his body and extremities.

"For the wave-current I employed an electrode 10 inches in length by 1 1-2 inches in width. I employed the current for twenty minutes to the upper portion of his spine and then the same length of time to the lower portion, following this with the frictional and indirect sparks. This treatment was employed daily for two weeks, and then every second day.

"The effect of the treatment was almost magical. After the sixth treatment he was able to walk through two rooms in my offices to the operating room. He continued to improve steadily, but his left hand and arm were least responsive

to the treatment, and he did not regain their entire control until some time in August. Since then I have been treating him very irregularly, as he thinks he is well.

"He was able to row a boat and play ball and football during the latter part of the summer and fall.

"There is still some atrophy of the muscles of both hands and forearms, and a little in both legs below the knees. To see him walk one would hardly notice anything wrong with him, unless he was very observing. The boy does any kind of work he chooses to do, and there is no difference in the strength of the limbs on either side.

"Each treatment was of about forty-five minutes' duration; twenty minutes each to the upper and lower portions of the spine, and about five minutes to the indirect and friction sparks. With the wave-current, the spark-gap was about one inch at the beginning of each treatment, but was gradually lengthened to five or six inches. (The machine was an eight-plate Holtz machine, having plates thirty inches in diameter.)

"I am fully satisfied that, had the treatment with electricity been commenced as soon as the disease showed itself, the atrophy of the muscles would have been prevented.

"This seems to me an exceptionally good result for so severe a case of anterior poliomyelitis."

This case so well illustrates both the method and results of static treatment that, with the doctor's consent, the record is included in full.

The same results have been obtained in other cases, and without exception, when the treatment has been instituted early. After two months have elapsed, however, the prognosis is very different and the treatment less satisfactory. In other words, when the pressure of the inflammatory process, or its effect, has not been relieved for so long a period, the ganglion cells perish, and paralysis then persists. It is certainly wise, however, to pursue the treatment so long as there is any improvement, because the disability may have resulted from a temporary involvement of the trophic centers, and some ganglion cells may not have perished, but their relations to the affected muscles have become such that the performance of their functions remains unimpaired. The results from treatment can be explained in no other way. After a year has elapsed the chances of improvement are poor indeed. Cases of anterior poliomyelitis have been chosen to illustrate the fact that congestive conditions can be relieved by the electro-static modalities. The other affections of a congestive or inflammatory character are to be considered in the same category, as has been shown in the preceding chapter, when considering the treatment of tabes. The management in all cord cases is practically the same as there described, and will not be repeated, except to impress the importance of administering the current with sufficient energy to reach the part affected; while, when treating very large muscular or fat individuals. it may require relatively small electrodes and a spark-gap of ten or twelve inches. There is no danger of making it too great, if it is not disagreeable to the patient. An intense penetrating effect is demanded.

When the lesion is of the brain, less can be accomplished, but the wave-current over the cervical region, and the brush-discharge vigorously applied over the scalp, will be fairly effective.

BELL'S PALSY.

With cases of Bell's palsy no other measure is so prompt and effective, because it is, as a rule, due to a congestive lesion. The writer has not infrequently known cases, which have come under observation within the first days, to be cured within a week. The cases in which the lesion is supra-nuclear or cortical, which are relatively rare, are recognized from the fact "that the upper muscles of the face are but little affected (the orbicularis palpebrarum and frontal muscles), the muscles which go to the angle of the mouth suffering chiefly."

The peripheral cases are most commonly of neuritic origin, arising from exposure to cold, as from draughts of cold air, and are promptly relieved by the administration of the wave-current and brush-discharge, if treated early.

The application of static electricity to the relief of congestion is to all intents and purposes the same, without regard to the location, for it is never employed with danger or possible risk to the structure of organs, even of the brain or spinal cord,—because, however high the voltage, the amperage is infinitesimal. Only judgment, tact, and patience are required to obtain generally satisfactory results.

Paralysis arising from a specific cause, as syphilis, calls for specific treatment, with a view to removing the gumma tumor that is supposed—rarely demonstrated—to be present, and the mixed treatment, or some other, may be followed by recovery. In such cases the administration of Franklinism for its nutritional effects, if for no other, is certainly beneficial.

The second general indication, to preserve the local nutrition of the parts paralyzed and promote the general health and nutrition, requires attention from the onset of the affection if an early and complete restoration is to be expected.

The maintenance of nutrition in health requires activity of the vital functions and a regulation of the activity of the motor mechanism. When either is interrupted, every part suffers.

If the action of the trophic centers in the cord, which are now believed to control the nutritive processes, is impaired, thereby complicating the paralysis, the part affected rapidly becomes soft and atrophies. In brain lesions the motor mechanism suffers only from disuse, and thereby only secondarily affects the general nutrition. In peripheral paralyses, if exercise of the other portions of the body is not thereby impaired, only the part paralyzed suffers.

If the general health of the individual is not good at the onset of an attack of paralysis, restitution will be relatively slow, and the utmost must be done to assist and even stimulate the normal activities.

It is certain that, while attention to diet, daily evacuations, judicious use of tonics, and regulation of exercise (when possible) are all important, no measure so well meets all the indications for improving or maintaining nutrition as static electricity. (1) It tends to preserve the balance of the nutrition of exercise and the nutrition of restoration, and thereby retards the process of regeneration. (2) The qualities of the currents are such that no unfavorable electro-chemical action takes place to impair the beneficial results. (3) The effects are searching, penetrating, and potent; in which qualities it surpasses all other forms of electrical administration. (4) Applied with the patient insulated, local administrations are tonic and constitutional as well. (5) Local applications induce reflex actions in cerebral cases, acting as a *vis a tergo;* not performing the action for the part, as when it is massaged. In other words the normal relations of center, nerve, end plate, and muscle to action are preserved, pending a possible recovery, in which the masseur fails, because he moves the limb while the parts are passive. (6) Contractures never take place during a course of electro-static treatment, nervous irritability is allayed, sleep promoted, and normal equilibrium preserved.

The static modalities of value in preserving and promoting nutrition are sparks (long, short, and friction), the wave-current, and the brush-discharge. No modality calls forth so well a healthy responsive reflex action as sparks, long and short, according to the indications—short sparks to small muscles, and longer ones to large muscles, and when a thick layer of fat overlays the muscles to be treated.

Over paralyzed muscles the applications should be numerous, not alone for exciting muscular contraction, but also to stimulate all local activities. For the same reason it is the writer's custom to make a thorough application of the friction sparks over the paralyzed areas. When anæsthesia is present, the friction sparks should be applied for a considerable time, after which in many cases partial or complete return of sensation will be experienced during the administration, to be followed later by partial or complete recovery. In paralysis of cerebral origin, peripheral paralysis, and in the treatment of tabes dorsalis sparks are of inestimable value.

The wave-current may be applied, when possible, for its general nutritional effects, in cases of paralysis.

Its local application, when a spark-gap of at least four

inches in length is continued for a period of twenty to thirty minutes, will preclude the necessity also of a tonic administration. The wave-current is also indicated over local peripheral congestion and paralysis originating from affection of the cord, as previously shown. When the brain is the seat of the lesion, applications to the cervical region may be of some service. Except the scalp is shaved the wave-current cannot be applied, and even then the writer's experience to the present time has derived no results that warrant its employment.

In the treatment of anterior poliomyelitis in young children, in addition to application over the spinal cord, the limbs may be put up in a bandage of tinsel braid, and the wave-current employed with a spark-gap just as long as can be used without inducing muscular contractions. It is best in these cases, we believe, unless the child is very small, to treat but one lower extremity at a time, but always both at the same sitting. When treating very small children it will be necessary to tie the child to the chair, or to instruct the mother to hold the child, at the same time pressing the palm of the hand *constantly* against the outer metal surface of the electrode or braid—otherwise the mother could not hold the child, because of the passage of sparks through the clothing.

The brush-discharge is valuable for its effect over areas of congestion and hyperæsthesia, for relief of pain, and as well, to a satisfactory degree, for its nutritional effects. It is the form of application *par excellence* to the scalp, and often affords great relief to an aching head.

The other modalities may be found of some value, but are, as a rule, not sufficiently effective to be indicated.

CHAPTER XIV.

PATHOLOGICAL MUSCULAR CONTRACTIONS.

MUSCULAR contractions are induced by stimulation or irritation of a nerve center, axis cylinder, or the end plate,—centrifugal or centripetal,—and are voluntary or involuntary. The voluntary contractions, subject to the will in certain instances, from habit and without manifest source of irritation in neuropathic individuals, become involuntary, as is the case in one type of convulsive tic which is amenable to suggestive treatment. The involuntary contractions are reflex in character, and comprise those which act in performance of nature's normal functions governed by special centers which control the natural processes of life, and those which arise from central or peripheral pathological conditions.

Muscular contractions classified by symptoms may be divided into spasms, contractions, and tremors. The first may be subdivided into two types, clonic and tonic. Clonic spasms are characterized by alternate contraction and relaxation of the muscle or group of muscles affected. Tonic spasms are those in which the action of the stimulant is constant or recurrent, with a frequency that maintains the muscle in a state of fixed contraction. When clonic spasms are general, they are known as convulsions. A contracture may be defined as a condition in which the contraction of a muscle or a group of muscles maintains a limb in a fixed condition of some degree of flexion or extension. Tremor is a condition of slight recurrent contraction, physiological after exertion or fright, or pathological under certain abnormal conditions.

The indications are, as in all cases, the removal of the cause—either an existing source of irritation, when present, or a nervous susceptibility which permits undue reflex contractions which, under normal conditions, would not be induced.

The prognosis in all cases will depend upon the chronicity

of the case, or the organic character of the lesion, as concerns the central nervous system.

Peripheral affections, when not of over two years' standing, as a rule are capable of being cured, but may require persistent application. In accord with the rule in all affections, the time necessary to effect a satisfactory result, other things being equal, is in proportion to the time which the condition has existed. In cases of central origin, if the affection is functional, from whatever cause, the prognosis again is favorable in proportion to the chronicity. The history of the case and the careful differentiation and diagnosis must afford the basis for prognosis.

In the treatment of these cases the high-potential electrical modalities, associated with hygienic and tonic measures in cases of non-specific origin, offer effective means of relief.

In these, as in the pathological conditions considered in the preceding chapters, such favorable results are due to (1) the constitutional tonic effects; (2) the local effects upon inflammatory (irritating) conditions; and (3) the sedative effects upon overwrought nervous conditions. The general principles of administration apply here as in other affections, but some special features of method call for consideration.

EPILEPSY.

When not due to traumatic causes, but occurring in children of neuropathic parentage, very much can be accomplished to prevent it from becoming established by removing all irritating influences, correcting diet, and employing systematic administration of static electricity, and for its general tonic effect for the relief of nervous irritability. The wave-current is the choice of modalities in these cases. Place over the abdomen or back a metal electrode having a surface of about sixteen square inches. The administrations should be daily, or every second day, for a period of not less than twenty minutes, employing a spark-gap of from two to five inches, according to the age or condition of the child. This course should be kept up for at least a year, or longer if there is improvement,

but a disposition to recurrence. If no lessening of frequency is noted after months of treatment, continuance will as a rule be of no avail.

CONVULSIVE TIC.

Very many of these are cases of habit, induced by some trivial local source of irritation or reflex influence not of central origin. In such, static electricity plays a double rôle, and is uniformly successful if applied early. (1) It lessens the irritability, and (2) acts as a powerful suggestive influence when systematically employed.

Most cases of central origin are not due to any traceable organic defect, but are induced by functional derangement. Such are capable of being cured if not of too long standing. For treatment apply a metal electrode covering the affected muscles to be held in position with the hand, and employ the wave-current with as long a spark-gap as can be used without causing painful muscular contractions. Sparks to the region will also render the results more effective in some cases. If the condition is suspected to be of central origin, a large electrode to the back or abdomen should be used, as in epilepsy, for an additional fifteen minutes for its general effect. Under this régime there are few cases of not more than two years' standing that will not yield.

BLEPHAROSPASM.

This affection is in the same category with convulsive tic, and treated in the same manner. It may be necessary, in making the application over the eye, to take off the ground chain when using the wave-current. In this be guided by the patient's sensation. With the ground chain in position it will not be possible to use a spark-gap of more than one-quarter inch, which, during periods of humidity, will discharge the machine. An advantage with sensitive subjects, in using the current with the ground chain removed, is the fact that the increase may be made by insensible gradations, and without causing unpleasant shocks to the patient. When using the

current grounded, lengthen the spark-gap with the greatest care, to avoid unpleasant (not dangerous) sensations to the patient. This is best accomplished by a screwing movement with the hand upon the handle of the discharging rod.

CHOREA.

This disease is favorably affected in many instances by the use of the various static modalities, sparks excepted. Either employ static insulation with the administration of the spray or brush-discharge, taking care that no sparks be administered to the surface of the patient, or else use the wave-current. In most cases, the latter will give the best results and should be administered daily for periods of from twenty to thirty minutes, employing a spark-gap not long enough to create any disturbing sensations to the little patient. It is essential in these cases that the patient be placed completely at ease by a reassurance of the freedom from any possible accident or danger. A cheerfulness which will inspire confidence will contribute much to the recovery. An austere and unpleasant personality without confidence, will, on the contrary, detract from the results of the static treatment, whereas under opposite conditions the relaxation induced and lessened nervous irritability, with restoration of normal function, will induce a prompt recovery in most cases. Patients who are annoyed by the vibratory influence of the wave-current or the noise of the discharge at the spark-gap will be benefited by a removal of these features, either by diminishing the length of the spark-gap, employing a muffler which will lessen the noise, or the use of static insulation. The latter is far less effective than the wave-current and should rarely be employed in its stead.

HICCOUGHS.

This affection in simple cases will require no special treatment. The distressing and dangerous cases, however, may often be relieved by the employment of the wave-current over the epigastrium or the vigorous application of sparks over the diaphragm, both to the back and front. When employing

the wave-current continue the administration for from twenty to thirty minutes and repeat the administration daily, or oftener if the paroxysms should recur. The result, in most cases, from either the wave-current or the administration of sparks will be to completely relieve the condition. Others of central origin may resist the treatment.

THE OCCUPATION NEUROSES.

These affections occur as a rule in neurasthenic patients, or those of strong neuropathic predilections.

The indications for treatment therefore are constitutional as well as local.

The prognosis generally depends upon the common rules governing chronicity. Not every case will be cured.

The *modus operandi* is practically the same in all cases, and the different types will, therefore, be treated collectively. Whether the sufferer be writer, typewriter, pianist, telegraph operator, or barber, it will be the flexor group of the right hand which is affected except in left-handed persons. While the writer has cured patients suffering from the affection without interrupting the occupation, it is not the best plan, and, in cases of longer periods than a few months' standing, should not be considered. In all cases employ the tonic treatment, with the wave-current for its constitutional effects, for at least twenty minutes, and thereby relieve the general nervous irritability and improve the processes of general nutrition. For this purpose the spinal or abdominal electrode and a three- to six-inch spark-gap are indicated. Locally a liberal application of short-sparks (one-inch) to the muscles of the forearm and ball of the thumb, followed by friction sparks, serves the best purpose. Their action is to improve local metabolism and nutrition, stimulate normal reflex action, and, with rest, or very moderate use of the parts, will effect a cure in most early cases, and is the best measure in all cases. In stubborn cases the wave-current may be employed, either by applying the tinsel braid or by placing the arm in a water bath connected by a metal electrode in a porcelain or glass vessel for a

period of fifteen minutes. The administrations should be made daily until a cure is affected, or the treatment abandoned.

CONTRACTURES.

These conditions are secondary to central or peripheral stimulation constant in character, or to paralysis of opposing muscles, and are curable in most cases if treated before the structural changes, which eventually shorten the muscles, are not too far advanced. Whenever an inflammatory process continues for a length of time in the structures of a movable joint in any part of the body, groups of muscles which control the action of that joint become contracted, and the limb becomes fixed in extension or flexion, because long-continued irritation of the nerves induces contraction of the muscular filaments. If the condition has been present for only a few months, the prognosis is excellent and the affection will be relieved when the inflammatory joint affection is cured. (See Treatment of Joints.) When treating these conditions, apply sparks liberally along the course of the contracted muscle. This latter means serves better than any other to overcome muscular contraction.

In addition, systematically employ therapeutic exercise. In cases which cannot be induced to submit to sparks, the wave-current will succeed, but requires a longer time to accomplish the same result. Contractures occurring with paralysis may be prevented, if treatment is initiated while the muscles may still be extended by gentle manipulation. In anterior poliomyelitis (q. v.), either electricity or orthopedic measures will prevent contractures. The objection to the constant use of fixation braces is that a degree of early restoration which is often possible is thereby prevented, and the opposite group of muscles atrophy, to an extent, as well, from which they may never recover if restrained throughout the period of development. If the orthopedic appliances are used, there should be a considerable period of each day during which the muscles should be exercised, and the wave-current or sparks (preferably the latter) may be administered at least three times weekly. (See Treatment of Paralysis.)

Contractures in hysteria, like the condition itself, yield to static electricity as they do to no other method of treatment. Sparks applied directly to the contracted muscles, or when not tolerated by the patient, long administrations (twenty minutes) of the wave-current, as strong as it can be given without causing painful muscular contractions, will succeed, but not so promptly. Contractures associated with other affections, as paralysis agitans, lateral sclerosis, cramps, etc., etc., should be treated on the same general principles, and the prognosis will vary with the chronicity of the affection and the organic nature of the primary lesion.

ATHETOSIS.

This condition often follows hemiplegia in childhood, and is characterized by varying degrees of irregular tremor of the hands and feet, and inability to retain the fingers and toes in a constant position. The prognosis in these unfortunate cases is never good. The lesion is fixed and central, and while others have reported relative success from electro-therapeutic treatment, the writer has never known a case to improve. If an effort is made, it should be along the same lines as in other spasmodic cases, and but little encouragement should be given.

TORTICOLLIS.

Contractions of the muscles of the neck may arise from myalgia or other sources of local irritation, or the affection may be congenital. The former yield very promptly to sparks, the brush-discharge or wave-current, if treated before a chronic condition of muscular shortening is established. The congenital cases are from the nature of the affection not improved by any but surgical measures.

SPASMODIC TORTICOLLIS.

Up to the present time no central lesion has been discovered that could be associated with this painful affection, and until recently the prognisis has been grave, and is now in cases of more than two years' standing. If, however, these patients

are treated in the early stages by the high-potential modalities, few indeed will not be satisfactorily cured.

The neuropathic tendencies so often present in these patients necessitate the early adoption of the constitutional, as well as the local methods of treatment, as is done in epilepsy, chorea, and the occupation neuroses. The wave-current alone will succeed in very many of the recent cases; but sparks will be invaluable in the treatment of cases of a few months' duration.

TREMORS.

These signs of lessened nerve force may be due to alcoholic or other excesses, overworked mental or physical conditions, or organic disease of the central nervous system.

The prognosis depends on the ability of the patient to correct the habit in the early stage, the chronicity, and the character and stage of the organic disease.

The treatment is the removal, if possible, of the cause, and the employment of constitutional and local measures indicated. In most of these cases daily administration of the usual tonic application of the wave-current for from twenty to thirty minutes, followed by a mild general administration of short sparks, closing the treatment with a rapid application of friction sparks to the whole body, will be most effective. This plan of treatment will meet the requirements satisfactorily in cases due to functional derangement, and greatly benefit, but not cure, cases of paralysis agitans, and multiple sclerosis. It will also often relieve fibrillary contractions of progressive muscular atrophy.

ASTHMA AND HAY FEVER.

These affections belong to the neuroses, and are more often acquired than inherited, though unquestionably there is an inherited predisposition present in very many cases.

Few, however, who have it in childhood are afflicted in later years; while, on the contrary, those who acquire the disease in adult life are rarely cured, except by removal to some climate

adapted to their own cases, if such they are so fortunate as to find it.

The writer, during the past few years, has been so favorably impressed with the results derived from the wave-current in the treatment of these cases that he has reason to hope that patients may be made comfortable or cured by these means. Especially is this true of asthma. A patient is often promptly relieved of the paroxysms by the administration of the wave-current.

Place a metal electrode having an area from twenty to thirty square inches over the chest in front, gradually open the spark-gap from three to ten inches, and continue the administration for thirty minutes. The amount of relief afforded in most cases is surprising, as well as the period for which the relief continues. Enough evidence has not been collected at this time to furnish any definite assurance that the results are more than palliative. The relief derived, however, warrants its use, and there are good reasons to expect that time will demonstrate cures in many early cases.

For the treatment of hay fever, the writer would cordially advise the employment of the glass electrode shown in Fig. 26. The application should be made at first twice daily, when possible, and continue at each sitting, which may be once or twice daily, until the condition is very much relieved. The application should be made to the nasal mucous membrane upon each side and care taken also to reach the turbinated bones. If the application is made thoroughly, the local congestion will be greatly relieved and the hyperæsthesia materially lessened.

CHAPTER XV.

STATIC ELECTRICITY IN DERMATOLOGY.

ALTHOUGH this field is relatively new, it is already practically demonstrated that the wave-current, brush-discharge, and high-frequency are valuable means of relieving many stubborn skin affections.

The actions of these modalities in relief of skin diseases are both local and constitutional, but vary materially in their respective effects.

The wave-current induces active local secretions, stimulates local metabolism, improves the nutritive processes, and at the same time provokes an active elimination of effete and irritating accumulations. The glands become active and the circulation and other conditions are restored to the normal when only functional derangement exists.

The brush-discharge is especially valuable for its remarkably destructive effect upon germ life, due largely to the local oxidizing action of the ozone set free at the surface of application, but more particularly to the violet discharges so manifestly present and to which the methods of Finsen and other recent writers attribute the results derived from solar light and the Roentgen ray.

The high potential discharges as administered with the glass electrodes are especially useful in the treatment of skin affections and in its action and general effects somewhat resembles the brush-discharge. It is to be preferred in the treatment of conditions of the skin in which it is desirable to preserve a smooth, clear, complexion, as of the face, in the treatment of acne. It may be applied either directly from the machine, as described in the chapter on convective discharges, or in connection with the Files interrupter connecting the cord from the binding post on the positive side of the machine to the electrode and grounding the negative binding post, hav-

ing placed a Files interrupter, with the rod removed, in the circuit of the two poles of the machine. By this means, a current of very high frequency will be produced. A better method is the employment of the high-potential step-up devices which

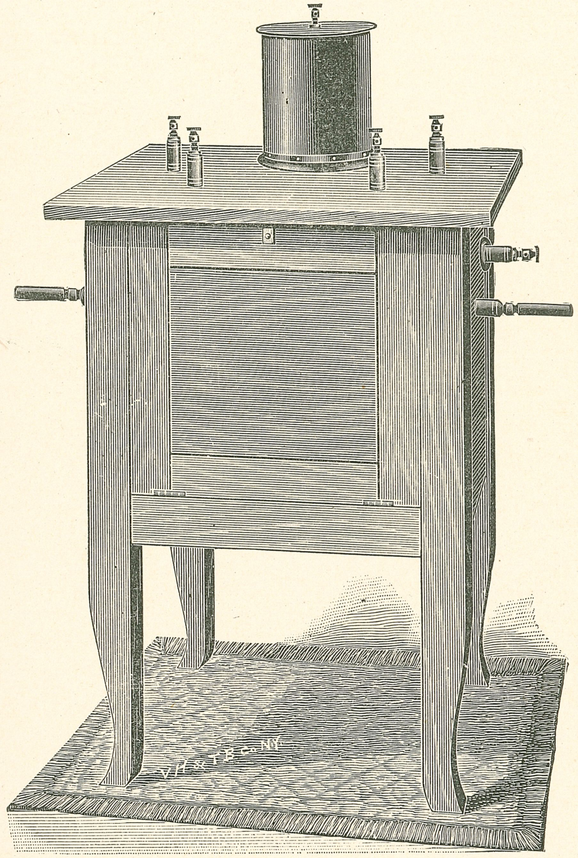


Fig 45.—Combined Tesla, Oudin, and d'Arsonval Apparatus.

are sold by most manufacturers of static machines, one type of which, combining the Tesla, Oudin, and d'Arsonval currents, is shown in Fig. 45. The small sparks administered with a glass vacuum tube from the Tesla coil of the apparatus are especially efficacious in the treatment of both types of lupus,

eczema, psoriasis, ulcers, herpes—in truth, it is difficult to say in what form of skin diseases this type of administration is not beneficial. While the brush-discharge is also beneficial in the treatment of the above conditions it has a disadvantage, stated before, as producing a thickened and roughened condition of the skin which contra-indicates its use upon the face for a series of administrations.

The *modus operandi* of these modalities is, (1) local destructions of micro-organisms, (2) stimulation locally of normal metabolism, (3) diminution of local œdema and congestion, (4) relief of local pain and pruritus (5) the promotion of normal secretions, as implied in the effects upon metabolism.

The effects upon the local conditions, when ulcerations are present, are to promote healthy granulation with a minimum of scar and to an extent unprecedented by other measures in the treatment of these conditions. The newly formed skin is even and of the texture of a young child's. When applied to carcinomatous ulceration it removes fetor, relieves painful sensations, and greatly improves superficial conditions. When hyperæmia, swelling, or œdema is present, it is often relieved to a remarkable extent by a single administration, and soon, in a large variety of cases, the local lesion disappears.

The local actions and effects suggest their application to a large variety of skin diseases—in few indeed do they seem not to be indicated, either alone or in connection with the X-ray or light treatment. (See Chapter IV., Section III.)

The brush-discharge of negative insulation from the static machine, employing the wooden electrodes, has, in the hands of Dr. J. D. Gibson of Birmingham, Ala., cured in twenty administrations a stubborn case of lupus vulgaris covering fully one-half of the face.

In many diseases of the skin the local manifestation is the indication of a constitutional derangement, resulting from organic functional inactivity. In those cases in which the affection is not entirely local, excepting the specific exanthemata and syphilis, the constitutional static treatment proves of certain value, as would be expected.

The method of employing the brush-discharge in these cases is essentially the same as in other conditions.

The time devoted to the administration, and the intensity of the application, must depend largely upon the experience of the operator, and will be varied in individual cases. The administration, however, must be thorough and necessary time not cut short.

The intensity of the application may be varied by the speed of the machine, the distance from the surface at which the electrode is moved about, the presence or absence of a direct ground connection, the distance at which the ground connection is held from ball or point of electrode, and the material and character of the electrode. If a wooden electrode is used, much depends upon the quality of the wood. The grain or texture should be uniform and possess poor conducting properties. Soft maple and whitewood are the proper substances, and may be varied by wetting the end from which the application is made. The form of the electrode will vary the character of the discharge. From the round ball it is coarse, and causes a sensation as if hot sand were thrown against the surface. When the point electrode is employed the discharge is fine, soft, and agreeable, but the desired effect is derived at the expense of time. The point electrode is indispensable in administrations in clefts, as between the fingers.

During cold weather the wooden electrode becomes less effective from the fact that such material, when cold, is a poor conductor. Warm the stick throughout the whole length before using, and it will be as effective as during the summer months.

CHAPTER XVI.

PSYCHICAL AND FUNCTIONAL NEUROSES.

THE nervous system, under control of the mental and reflex influences, exists in such intimate relation with every physical function that the health of the organism depends upon the preservation of the normal activity of each—*mens sana in corpore sano.*

The psychical neuroses result from causes arising from both mental and physical derangements, and to locate the correct relation of cause and effect often taxes professional skill.

Environment, associations, habits, and inherited neuropathic tendencies play no small part in determining the state of the individual, and cannot be ignored in considering either the prognosis or treatment.

The moral as well as the physical features require consideration in outlining the course to be pursued in the management of the neuroses. In fact, the successful physician takes cognizance of the psychical side, no matter what the lesion with which he is called upon to contend. Cheerfulness and hopefulness greatly enhance the medical value of any remedy. Agreeable surroundings and encouragement, together with a gradual return to a proper activity in some congenial pursuit, which partakes to a large extent of physical exercise, are conducive to the fullest measure of success in the treatment of the psychical neuroses. Rest enervates, and lessens thereby the activity of the very processes essential to restoration when forced as a therapeutic measure. Rest and massage lack initiative. The normal relations of the nervous system and the muscular or functionating organs are designed for concerted action. Neither passive motion nor rest affords an incentive to restoration, and consequently does not induce the normal processes of nutrition. A physical agency to restore lost nerve force, and organic functional activity, must be general in its application, promoting activity in the cell structure of every part of the organism. To activity add a proper nutritive pabulum, congenial environment, and well-regulated exercise, and all indications will have been served. The essential law of life is activity. The body recuperates during rest most vigorously when rest follows exercise.

The differentiation of the physical neuroses which are functional and those which are organic in character has been the source of some confusion, especially among general practitioners.

The distinction, generally well marked in typical cases, often affords occasion for doubt in those which are complicated, or on the border line. Neurasthenia, melancholia, and mania are distinctive in their characteristics, but often lead from one to the other, marking the advancing stages toward a chronic organic condition. Hysteria and hypochondriasis may properly be considered as symptoms of neurasthenia, but they present distinct and characteristic features.

NEURASTHENIA.

This common affection, classed, as it properly is, with the neuropathic conditions, partakes in every case of some functional or organic derangement which either may have been primarily the cause of the nervous exhaustion or has resulted from it. Whether induced by irregular habits, business requirements, or worry and trouble, added possibly to an inherited neuropathic or functional predisposition, when the breakdown is manifest it will often be difficult to decide which is the predominating cause to be removed.

The symptoms most common are insomnia, pain in the head, especially marked over the region of the medulla, anæmia, indigestion, constipation, a generally sluggish or irregular action of the organs of secretion and excretion, irregular action of the heart and præcordial pain (false angina), to which may be added the train of symptoms associated with hysteria or hypochondriasis. It may be induced by impaired nerve force, or associated with other derangements which have been instrumental in causing neurasthenia.

The prognosis when organic disease is not present is good. The time necessary to effect a cure depends upon the duration of the affection, the probability of removing the cause, changing the environment or other circumstances unfavorable to the patient. If agreeable home surroundings cannot be provided, these patients are best managed in an institution provided with the means of meeting every indication.

The treatment calls for removal of the cause, correction of hygiene, etc., as suggested above when considering the general management of any of the class of conditions under discussion.

The electro-static treatment undoubtedly meets more indications, and as efficiently as any other method, because (1) it quiets nervous irritability, (2) controls local congestions, active or passive, (3) promotes general functional activity, (4) relieves pain, and (5) induces natural sleep, thereby restoring to the sufferer the conditions which lead to the re-establishment of the functions. Treatment of the constitutional and local conditions, whether the local lesion be abdominal, pelvic, præcordial, spinal, or prostatic, is indicated. At the particular region make the application of the electrodes, when the wave-current is used, adapting the size of the metal plate to the idiosyncrasies of the patient, employing an electrode large enough to permit of using a spark-gap four or more inches in length, for a proper constitutional effect, and at the same time small enough to concentrate the effect upon the local condition.

The treatment of the local affection in this manner at one application results in the relief of both conditions.

Dysmenorrhea and other pelvic conditions associated with local congestion of a simple inflammatory character are so often associated with neurasthenia and hysteria that the first indication with many of these patients is to relieve the local trouble. Too often does it happen that recurrent menstrual periods, accompanied by terrible suffering, tax the nervous and physical energies of the patient until she becomes a victim of neurasthenia. These sufferers may be treated during the intermenstrual period with sedatives, anti-spasmodics, hypnotics, etc., with a possibility of lessening the severity of the

next attack. To relieve the condition which causes this suffering with the static modalities in cases in which an acute flexion is not present, is often not a difficult matter. The same general principles are to be employed as when treating a sprained knee or a congested sciatic nerve. Adjust an electrode so that the current will be applied near the congested organ. This may be done either by placing the long rectal electrode or the one shown in Fig. 46 in the rectum and employing the wave-current twenty minutes daily during the intermenstrual period. The location of the electrode may be varied by placing a large abdominal electrode over the pubic region or a good-sized vaginal electrode, so constructed as to press into the posterior fornix and provided with a concave depression in which the cervix will rest. When the current is administered in the vagina or rectum, the spark-gap which measures the strength of the current should be from four to eight inches long. The writer has treated a case of neurasthenia which had undoubtedly arisen from dysmenorrhea, in which the electrode shown in Fig. 47 was placed in the rectum and held in position against the lower segment of the uterus and the recto-vaginal septum. After one month's treatment the patient had the first painless menstruation in fifteen years. The treatment was continued during the next intermenstrual period with the same result. Since then her menstrual periods have been free from suffering. The neurasthenia in this case vanished with the restoration of the normal condition.

This treatment for dysmenorrhea in young girls will be successful in many cases, and from the fact that the rectal electrode may be employed, is free from all objections. The employment of the wave-current in pelvic conditions such as chronic cellulitis, ovaritis, prolapsus of the uterus, arising from atony or relaxed condition of the vagina, and general local hyperæsthesia are greatly relieved and often cured by the local use of the wave-current or glass vacuum tubes. In some of these conditions the local use of the brush and high-frequency discharges over the hypogastric and iliac regions will be employed beneficially. (See Ovaritis.)

Sexual neurasthenia in the male is one of the most stub-

born types of this neurosis. Many of these cases arise from a real or imaginary impotence, and are often associated with an acute or chronic inflammatory condition of the prostate gland or seminal vesicles or both. As in the treatment of dysmenorrhea, the effect with the wave-current, employing a rectal electrode, is phenomenal.

In impotency which is due to psychical impressions or hypochondriasis, the psychical effects of static electricity, of which so much is said by those who know little of the other effects, is here recognized by all. The local vibratory action of the strong current applied in the rectum is often described as being

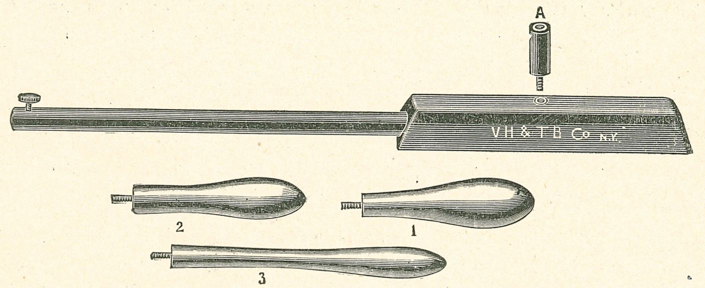


Fig. 46.—Set of Rectal Electrodes. *A*, vulcanite section for relieving anal contraction. 1, short rectal; 2, constipation electrode, to be used without insulated portion; 3, long rectal.

felt to the end of the penis. This administration should be continued for at least twenty minutes, and may be followed by applications of sparks to the perineum, and friction sparks to the penis, if the case demands it. The tonic nutritional effect of the treatment is certainly one of which the physician can conscientiously make much to the patient, and either cure him by suggestion, the physical effect of the current, or both.

In the treatment of prostatitis, acute or chronic, the use of suggestive therapeutics fails, but the result from wave-current administrations in these cases is triumphant. The application should be made with an ordinary electrode of metal or a special one about five inches in length adapted to the conformation of the gland and reaching to the seminal vesicles. (See Figs. 46 and 47.)

The writer has designed a special electrode for the treatment of this affection which is also applicable to the treatment of other pelvic congestions, as well as constipation, which is shown in Fig. 47. In the treatment of prostatitis, any of the electrodes may be used either with or without the insulated section, according to the demands of the case. In patients with whom there is no indication for the treatment of an associated constipation it will be desirable to use the insulated section, thereby relieving the sphincter muscle from an unpleasant contraction which would otherwise be induced. The base

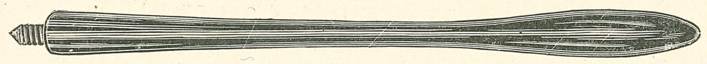


Fig. 47.—Rectal Electrode.

may be set either flat upon the chair or elevated at either extremity, in order to bring a proper pressure or contact with the diseased prostate.

The spark-gap in these cases should be regulated, as in all painful and inflammatory conditions, gradually increasing it as tolerance permits. The application of the current in this region should allow before the close of an administration the use of a spark-gap of from six to twelve inches.

The use of the rectal electrode may be varied by the employment of a urethral sound of as large a size as can be conveniently placed, carried to, but not into the vesical sphincter, where it would produce a disagreeable contraction. The spark-gap here, as in the rectum, should be regulated to the sensation produced and may be from four to eight inches in length. Many cases will be more benefited by the employment of an electrode in this position than in the rectum. In others the combined use will produce the best results.

In cases in which gleet or a suspected ulcerative or specific process in the deep urethra is present, the high-frequency glass vacuum urethral electrode may be employed with great advantage, to be used daily following the application of the rectal electrode.

The effects upon the local conditions are to promptly relieve the symptoms of congestion, pressure, and irritation, with

prompt restoration to health. No cases which have come under the writer's observation have afforded him greater satisfaction than the cases of prostatitis treated by the wave-current. The cases of neurasthenia arising from this cause, as a rule, need no other treatment and are promptly relieved of the nervous conditions upon the institution of treatment.

Seminal vesiculitis will be treated coincidently when associated with prostatitis and relieved by the same method, care being taken that the electrode is long enough to reach and that it be placed in contact with the rectal wall over the vesicles. The results in these cases are very satisfactory and far more effective than the method by stripping. Cases of three or four years' standing have been relieved with a few weeks of treatment. Probably no procedure employing static electricity will give greater satisfaction than the treatment of subacute and acute prostatitis with seminal vesiculitis.

Sensitive conditions over the vertebral column are relieved by the wave-current, brush-discharge, or sparks locally applied.

Præcordial pain, when due to high arterial tension or anæmia, yields promptly to the application of the wave-current. (See Angina Pectoris.)

Constipation is undoubtedly a common cause of neurasthenia, as are also indigestion and some pelvic derangements. Systematic applications of the wave-current followed by long sparks, especially over the colon, are energizing, but often require considerable time to effect a cure. Diet, mild laxatives, liberal ingestion of water, and regulation of habit, with static administrations, bring about the desired result in the shortest time and most effective manner. Secretions become more active, and tone is restored with a return of the normal peristaltic activity.

A method of treating habitual constipation by the static currents, brought to the writer's notice in a paper read before the New York School of Physical Therapeutics by Dr. Sigismund Cohn, and published in the New York Medical Journal of September 6, 1902, has been demonstrated to be of so great value that the following extract is quoted.

"I use static electricity, either in the form of the wave-current or of the static-induced current; the first in the milder forms of constipation, the latter in the very obstinate cases of long standing. The polarity is of importance, as the positive pole has a stronger effect on the tissues it is in contact with than the negative pole.

"In using the static wave-current the patient is in contact with one pole only, while the other one may be grounded or not. If we use a current without grounding, the treatment is a very mild one. By grounding we make the current considerably stronger. The contact with the patient is made either by the rectum (the patient sitting on the upright rectal electrode) or by the abdominal walls (tinfoil plate, 8″ x 10″). The current strength is regulated by the spark-gap between the sliding poles.

"The static-induced current enables us to use very powerful means without causing the patient any pain. The static-induced current, is, in reality, a current of high tension and high frequency. While the static wave-current distributes its strength over the whole body, the static-induced current concentrates its whole strength beneath and between the electrodes. The patient is connected with the outer surface of the Leyden jars, while the inner surfaces are connected with the poles of the machine. One electrode is generally on the abdomen, the other one either in the rectum (direct) or on the back (percutaneous). The current strength is also regulated by the spark-gap. As the patient need not be insulated, we can also use the labile method. (See Plate IV.)

"The powerful action of this current, as well as that of the wave-current, may be enhanced by a mode of administration called the undulating or swelling current. By this we understand a current that, starting from zero, gradually swells to a maximum of strength and returns in the same way to zero. By alternately increasing and decreasing this current we produce in the muscles alternations of wave-like contractions and relaxations. The effect of this mode of administration of the current is a tonic exercise of the muscles, and in using it we do not risk the danger of overworking and exhausting the muscles, as their maximum contractions are only of short dura-

tion. The circulation of the blood and lymph will certainly be accelerated by this milking-like process, and we can readily understand how the atonic condition of the tissues is improved. On the static machine we get the swelling current by slowly removing one pole from and then approaching it to the other."

The disturbances of the secretory and excretory functions, inactive or excessive, as the case may be, are caused by lost nervous tone, and normal activity is restored by the general treatment.

Insomnia, one of the most persistent and aggravating symptoms, soon yields to the long constitutional treatment, many of the patients falling asleep during the administration. The general relaxation, lowered arterial tension, with lessening of nervous irritability, induced as they are, afford the conditions favorable to sleep. For best results, the treatment should be given at night before retiring, if but one administration is given daily. Patients in whom nervous irritability is extreme should be given two half-hour sittings daily. In but rare instances will the noise of the discharging sparks of the wave-current unfavorably affect these cases. On the contrary, it is soothing to the far greater proportion of patients, as soon as any nervous apprehension which may be present is removed by convincing them that no possible harm can come from the use of such currents. Another precaution in these cases is to employ an electrode of sufficient size that no unpleasant vibration can annoy them, for which purpose a metal plate 6 x 10 or 12 inches, placed next to the integument upon the abdominal or lumbar region, whichever is most convenient, may be employed.

Insomnia will be incidentally overcome in most patients during the treatment of local conditions.

Impaired secretion, so remarkably demonstrated in the absence of activity of the sweat glands, will be observed in these cases. The writer, since employing static electricity in the treatment of neurasthenia, makes the important observation that in nearly all cases the secretion of the sweat glands is dormant. Upon questioning the patients it will be found that for some time, in many cases, they have noticed that they do not

perspire normally on exertion as they had before the commencement of the neurasthenia. After the institution of treatment, it will be found that for varying periods the secretion does not appear as normally during the treatment with the wave-current or sparks. In the average case, after the commencement of treatment it will appear in from five to seven days. In some cases, however, it has persisted for from one to three months and finally been restored to normal.

When it does finally appear, it will occur with subsequent applications. This same observation will be made in very many patients taking treatment for other affections, showing a tendency of this function to become inactive. It is a significant fact in most cases that a remarkable improvement in the constitutional condition takes place coincident with the resumption of this function, probably from the fact that other functions are restored to a greater degree of activity at the same time. The appetite returns, the patient becomes less irritable, and in most cases sleeps better during the first week. In those in whom the peripheral circulation is inactive, the administration of sparks, especially the friction sparks applied rapidly over the whole surface of the body, is productive of the desired result. Other conditions existing with neurasthenia, and the allied neuroses, call for the same general *rationale*.

HYSTERIA.

Hysteria is an impaired functional disease characterized by lost individual control, either mental or physical, or both, and marked by varying degrees of anæsthesia, hyperæsthesia, paralysis, contractions, or other perverted conditions. It arises from inherited predispositions, physical derangements, evil associations, and improper moral training leading to habits of indulgence often associated with a petulant, selfish disposition, which under disappointment, reverses, or other disturbing influences cause some individuals to become helpless invalids. They often do not receive needed support and proper sympathy from their relatives and friends, who from the popular notions, consider the condition one of shamming, when in reality

it is not. Few patients are victims of conditions demanding more skillful attention than these. The moral management is of great importance and demands an exercise of tact, with firmness, system, and the administration of measures of relief which exert positive physical effects from which the patient may derive the necessary reassurance. As in the neurasthenic conditions above considered, and for the same reasons, electrostatic administrations are particularly indicated in hysteria. The heroic application of sparks to those patients whose condition has resulted from overindulgence and petting serve, when administered under pretext of necessity, a most efficient therapeutic purpose.

Areas of anæsthesia should be treated each time by the application of friction sparks until sensation returns and the patient protests. Over paralyzed muscles and contractures apply sparks, or if the patient is feeble make use of the wave-current, or, over the clothing, high-frequency discharges applied with glass vacuum tubes.

Treat all other conditions according to the indications, observing in all cases the importance of the constitutional administrations of the wave-current for periods of not less than twenty minutes at each daily treatment.

HYPOCHONDRIASIS.

This neurosis is defined by Gowers as "a morbid state of the nervous system in which there is mental depression due to erroneous ideas of such bodily ailments as might conceivably be present." This state is termed hypochondriasis in men only, according to this writer, and when in women as forming part of hysteria. Again when the character of the delusion becomes such that the impression is fixed, that the imagined condition is actually present, it should be termed insanity. Melancholia is present in this condition almost constantly, with an inordinate brooding over an imaginary ailment. When the border-line between actual insanity is crossed in a given case, it is most difficult to discern, and most important on account of the danger of self-destruction.

In the ætiology of this condition timidity plays an important part, either as a neuropathic predisposition to tendencies, habits, or practices which vitiate and lead to a weakening of the mental poise, or from the fact that the mental status in the individual is abnormal from birth. Undoubtedly environment and the evil associations of youth pervert and destroy the normal status and lead to physical depravity in many cases as well. Dyspeptic troubles, which are so common in those with whom the care and hustle and bustle of business make such drafts upon their energies, together with the pernicious effects of quick lunches, constipation, and excessive use of stimulants, once established, lead to a most common variety of hypochondriasis. This type, under systematic management, is most amenable to treatment. Few indeed of the derangements of digestion cannot be relieved and cured under present systematic methods.

In a class of individuals who know just enough of their organization to imagine ills and evils which cannot exist, apprehension, fear, and attention to every reflex pain or other sensation discover ailments which are as real as if actually present. Dyspepsia, constipation, and the associated annoying discomforts of reflex palpitation, præcordial pain, movements of gases in the alimentary canal, and all manner of disturbing symptoms, awaken fear of dangerous organic disease, and are followed by consequent solicitude and despondency. Such conditions in the writer's experience are not peculiar to men, the same affection arises also from real or imaginary impairment of the sexual function in the male. In such it is caused, as suggested above, by masturbation, or excess of venery, and is probably more common than from all other sources combined. The reading of infamous literature issued from all directions by a disreputable class of charlatans who prey like vultures upon the uneducated and gullible youth and adult by the sale of electric belts and nostrums is a fruitful cause of suffering. It is hoped that the government will put a stop to such use of the mails, which is in itself worse than counterfeiting, blackmail, or the getting of money by illegal stock transactions, because it not only gets money by false representation, but destroys and vitiates the public mind.

The treatment of hypochondriasis depends upon so many causes requiring, not alone physical measures, but in many cases moral restraints and proper environments, that but partial justice can be done to the subject here. Attention to the digestive function when due to an actual gastritis, which should be differentiated by chemical analysis of the stomach contents, is indicated. Atonic or so-called nervous dyspepsia will be successfully treated in most cases by applying a large (4 x 8 inch) metal electrode over the epigastrium, and administering the wave-current with a spark-gap of four to ten inches in length. In gastroptosis, place the electrode over the displaced stomach and employ the same current and sparks. In all other respects use the same measures as indicated in the kindred cases described in this chapter.

Undoubtedly institution management for these patients is best calculated to meet all indications, both moral and physical.

MELANCHOLIA.

This condition is properly a symptom associated in varying degrees with each of the neuroses included in this chapter, and calls for no special indications for treatment not included in the preceding considerations.

FUNCTIONAL INSANITY.

By the above term we would include a large number of cases of mental derangement which arise from neurasthenia, hysteria, hypochondriasis, or other causes as fright, anxiety, or trouble, or occur primarily in persons who suffer from impairment of general health, in which no organic lesion of the brain is present.

The condition may be manifested by delusions, persistent melancholy, or emotional states in connection with which the patient may be thrown into fits of crying, laughing, or aimless movements of the extremities. The patients are apt to be sensitive to a strong light, and are annoyed by slight noises which under ordinary circumstances would not be noticed.

Headache is a more or less constant symptom. The peripheral circulation in a large proportion of these patients is feeble, they suffer from cold hands and feet, inactive secretions, and are usually of constipated habit. There is also apt to be a more or less constant condition of high arterial tension. The flushed face, injected conjunctivæ, headache, and hypersensitiveness, and insomnia so often present are indicative of intercurrent cerebral hyperæmia which is undoubtedly present in most of these patients.

The indications for the employment of electro-static administrations in these cases are apparent and the result most gratifying. The method is practically the same as in neurasthenia, observing the indications for treatment of any local condition.

The same rule should be observed in treating headache of the congestive type; i. e., during the administration of the static bath, or wave-current, the point of the stand electrode should be placed on a level with the knees, and at a distance that will cause a moderate, not disagreeable, warmth beneath the clothing. This method determines in great measure a current flow from the head and serves as a derivative, relieving the cerebral hyperæmia.

The wave-current, administered for at least one-half hour daily, is the best plan of treatment in these cases, but the noise, as a rule soothing, in a few instances will at first aggravate the patient. With these patients substitute static insulation for a few days, and later they are certain to become tolerant to the noise induced. To improve the peripheral circulation during the first administrations of the tonic treatment, pass the brush electrode rapidly over and around the patient at a distance that will produce a sensible warmth, or employ the brush-discharge from the wooden ball electrode (negative insulation), and later, when the patient becomes tolerant, thoroughly apply the friction sparks to the whole surface of the body.

The results from the above plan are, in most cases, gratifying. Static administrations are calculated to benefit many types of insanity, and the future will undoubtedly find the machines in daily use in all the great medical institutions of the country.

CHAPTER XVII.

MISCELLANEOUS DISEASES.

TUBERCULOSIS.

Tuberculosis, characterized by the presence of the tubercle bacillus, exists as a local affection, and may be present at the same time in one or more of the structures of the body.

Pulmonary tuberculosis, the most common form of the disease, has in the first, and less often in the second stage, been cured by measures which increase the powers of resistance and restore to a degree the normal nutrition with increased weight and gradual return to a state of health. The bacillus cannot exist in a healthy organism, and is never actively present until, for some cause, health and vitality have been impaired.

Any influence, especially in persons having an inherited predisposition, that reduces the vitality, predisposes to the onset.

The indications are twofold: (1) to destroy the bacilli at the site of invasion, and (2) to improve the health and powers of resistance of the patient.

The prognosis will depend (1) upon the stage at which the disease is recognized, (2) upon the character and extent of the cause, (3) upon the institution of proper restorative measures and their faithful employment. No single plan of treatment is applicable to every case, and no one measure sufficient to meet the indications. Of the province of electro-static administrations in consumption much has been written. The virtue, if any, of so-called static cataphoric administrations has little foundation in fact. On the contrary, there is sufficient evidence to prove that the static administrations act chiefly to improve the functional activities of the patient and thereby facilitate return to a normal condition. It is upon this assumption, now well-founded, that the consideration which follows will be based as ground for the employment of the static modalities in meeting the second of the above indications.

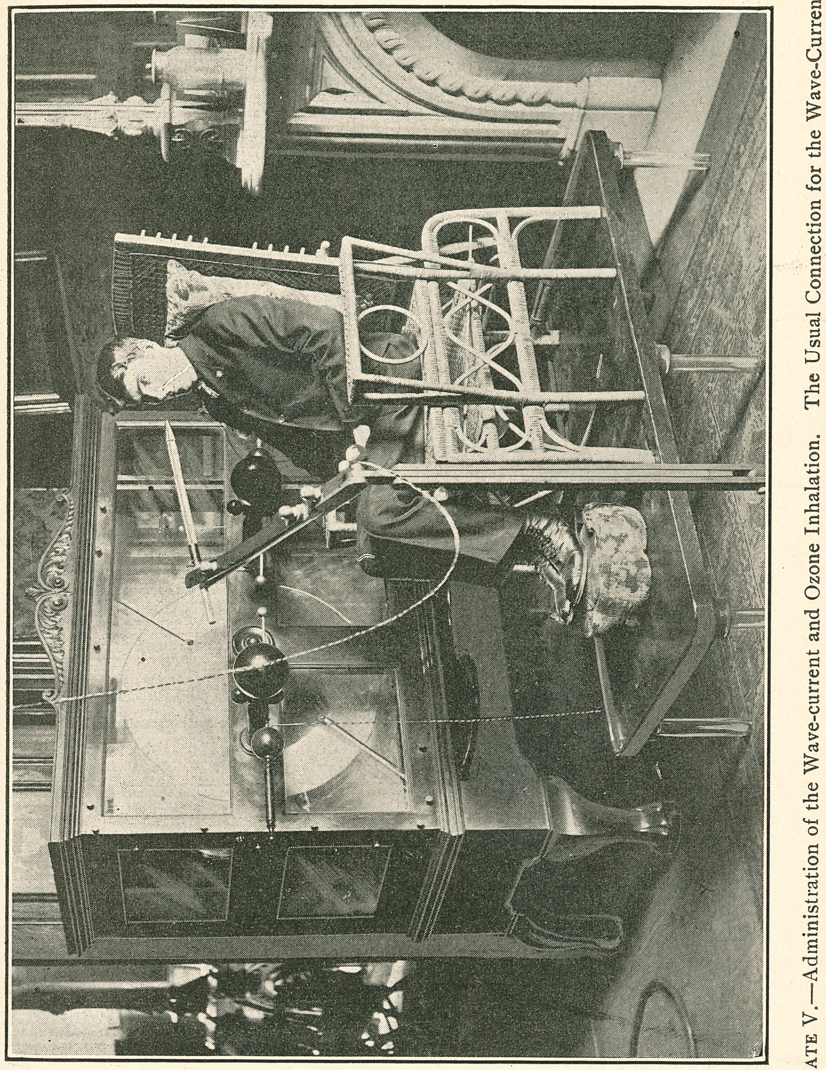


PLATE V.—Administration of the Wave-current and Ozone Inhalation. The Usual Connection for the Wave-Current, a Wooden Electrode with Ball or Point Placed at a Suitable Distance and Grounded to the Gas Fixture.

The first indication, when the lesion is of the lungs, is most difficult to relieve. The French, and some American writers, have contended that ozone may be brought in contact with the lesion and destroy the bacilli at the site of invasion. Dr. J. D. Gibson, of Denver, Colo., has shown that positive improvement is derived from inhalations in conjunction with allied measures.

If ozone can be brought in contact with infected areas, its effect upon the bacilli of tuberculosis is undoubtedly to destroy them, as is amply illustrated in the treatment of lupus vulgaris. At the present time attention is drawn to the employment of the Roentgen ray in the treatment of tuberculosis, both the pulmonary and other local forms of the disease. To date, however, little of a positive nature is established that will warrant more than the suggestion.

For the purpose of improving the general status in the management of every case, particular attention should be given to the sluggish or deranged physical functions. Place a metal electrode over the organs in question and with the wave-current give half-hour administrations, bearing in mind that by such means the patient will at the same time derive the desired constitutional effect, and if ozone is, as it probably is, beneficial, the patient will breathe an atmosphere impregnated with it from the constantly discharging spark at the spark-gap.

This plan of treatment, followed daily with careful attention to every function, together with care of the diet, environment, regulated rest, and exercise, will contribute in a large degree to the recovery of these unfortunate patients.

Another method, and one generally as effective as the employment of the various ozone inhalers for the administration of ozone inhalations, is shown in Plate No. V. It is customary when employing this method to apply the wave-current either over the spine or abdomen, according to the indications of the case, coincident with the ozone inhalations. The wave-current is used for its general tonic effect. The strength of the ozone inhalation may be regulated by varying the distance at which the wooden electrode, either the ball or the point, is placed from the nose of the patient. The ball electrode will

give off the strongest discharge, and in order to increase the richness of the discharge it is customary to ground the wooden electrode as shown in the plate.

Tubercular joints and glands will not be benefited by the local administration of the wave-current or sparks. There are reasons to believe, on the contrary, that these conditions are aggravated by the local static administrations.

If it were possible that the discharges of the brush-discharge were penetrating, as some would teach, the local effects of the ozone would certainly exert a curative action as it does in lupus, but experience disproves the notion.

Tubercular laryngitis, we believe, will be materially benefited by the administration of the brush-discharge, employing a special electrode, which must be insulated with vulcanite where it passes the fauces, or by employing the discharges from a vacuum tube.

Tubercular enteritis. There is no reason to suppose that any administration will favorably affect this fatal complication.

Lupus vulgaris yields most satisfactorily to the administrations of the brush-discharge. (See chapter on Dermatology.)

CHLOROSIS AND ANÆMIA.

Chlorosis and anæmia may be considered together here, for both are often secondary affections, arising from menstrual derangements in young women, infective or febrile diseases, chronic suppurative diseases, nephritis, dysentery, pregnancy, and other conditions which make excessive draught upon the physical resources. The proportions of the normal constituents of the food become altered and the relative number of the red blood corpuscles is especially reduced.

The indications are (1) removal of the cause, (2) iron and nutritive foods, (3) any agency that will induce functional activity without producing otherwise deleterious effects.

The prognosis is dependent upon the primary cause, and is especially good in all cases not complicated by serious malignant, suppurative, or organic affections.

The treatment of menstrual derangements characterized by the presence of passive pelvic congestion, spasmodic and other nervous conditions which are amenable to the local measures employing the wave-current, sparks, and brush-discharge, has been described in the previous chapter, when treating of the same conditions complicating hysteria.

The writer's attention was first called to the remarkable disappearance of anæmia when treating other conditions, in a clinic practice in which it was the rule to make use of no means other than electricity. In these patients, as the bowels become regular, and the other functions more active, the anæmia gradually disappeared. In private practice the same result is invariable where no organic, malignant, or suppurative disease is present coincident with the restoration of the normal functions.

The method of application must be governed by the conditions present, and the electrodes placed as indicated in the treatment of the peculiar constitutional and nervous affections.

DIABETES MELLITUS.

There are at present not sufficient data upon which to base positive indications or results in a sufficient number of cases to warrant more than leading suggestions. Employ the wave-current, placing an electrode of a surface area of about 5 x 8 inches over the region of the pancreas, regulating the spark-gap to the patient, as a rule making it four to eight inches in length. Such administrations should be made at least thirty minutes daily and in no wise contra-indicate the medical treatment of the disease.

If the lesion is congestive in character and of the pancreas, and the treatment instituted before structural organic changes have taken place, there is the best reason to expect a restoration of the normal conditions.

BRIGHT'S DISEASE.

The different forms of nephritis are all types of congestion, varying essentially in the parts of the structure of the organ

which is the site of the process. Here, as in all congestions, acute or chronic, the rule for treatment obtains.

The prognosis depends upon (1) the chronicity of the case, (2) the physical condition and habits of the patient, and (3) the particular structure of the organ which is the site of the lesion.

The principles of *treatment* in Bright's disease are in accord with the general rules of administration. Apply an electrode 3 x 9 inches over the region of the kidneys, the long dimension transversely, taking care that the metal is shaped to conform to the surface, and held in position by a pillow pressed firmly between the electrode on the body of the patient and the back of the chair. The wave-current should be administered for at least twenty minutes daily, employing a spark-gap of from four to ten inches, avoiding discomfort to the patient, but bearing in mind that the efficiency of the application depends upon the relation of the current to the underlying fat and muscular structures.

At the Buffalo meeting of the American Electro-Therapeutic Association, Dr. A. D. Rockwell of New York presented a paper, which was published in the Journal of Advanced Therapeutics for January, 1902, in which he reported most gratifying results in the treatment of several cases of Bright's disease by the high-tension coil and wave-current wherein he expressed his preference for the latter. Under the treatment the patient's secretions all become more active, local congestion is undoubtedly relieved, and the general health of the patient improves. It is, therefore, a rational measure used either alone or in conjunction with other therapeutic means which seem to be indicated.

CONGESTIONS OF THE LIVER.

Without entering into particulars as to the various congestions of the liver, active or passive, which, for the purpose of treatment, are considered in all to be practically the same, the prognosis in each depends upon the possibility of removing the cause, and the chronicity of the lesion.

In all visceral congestions the indications for electro-static administrations are practically the same as have been described when treating of nephritis, and the results warrant its general adoption.

The wave-current is the modality of great value, but in all acute conditions should be supplemented by an administration of the brush- or high-frequency discharges to produce a rubefacient effect over the region of congestion. The operation will consume considerable time, but the result will amply reward the expenditure.

MYASTHENIA GASTRICA.

The local and tonic stimulating effects of the electro-static modalities, especially of the wave-current and sparks, upon myasthenia gastrica are most remarkable and particularly adapted to other associated conditions. In no case will they favorably affect a catarrh of the stomach, but atony and relaxed conditions respond as to no other plan of treatment.

A potent administration of the wave-current for from twenty to thirty minutes, followed by a liberal administration of long or short sparks—depending upon the nature of the underlying structures—will meet the requirements.

EXOPHTHALMIC GOITER.

This disease, complex as it is in the peculiarity and remoteness of the organs involved, is favorably affected in most instances by judicious administration of the wave-current. In some patients the lowering of the arterial tension seems to unfavorably affect the heart's action. In most instances, however, there is a marked relief of the tachycardia, diminution of the size of the enlarged thyroid, and a cessation of the further progress of the disease, when the treatment is systematically carried out. The application of the wave-current should be local both to the thyroid and constitutional; applying the electrode for constitutional treatment over the epigastrium. Secure a metal electrode over the thyroid gland for local treatment, employ as long a spark-gap as will be permitted without causing unpleasant contraction of the

laryngeal muscles, and continue the administration for from fifteen to twenty minutes. Follow this with the tonic treatment for a length of time depending upon indications, but usually for about twenty minutes.

SIMPLE GOITER.

This form of goiter, before hyperplasia takes place, may be invariably cured by a few administrations of the wave-current applied to the gland, as in Graves' disease.

CONCLUSION.

In these chapters it has not been deemed necessary to refer to every condition in which the high-potential modalities are indicated, but by the classification adopted an effort has been made to treat the subject in such a manner that, by observing the general principles of technique, the reader may carry it into the broader field of general application.

To many who are familiar with the other electrical modalities, some expressions may appear narrow. Such will note that we were treating especially of the electro-static modes of administration, and have confined the work to the consideration of that subject.

SECTION II.

RADIOGRAPHY.

SECTION II.

USES OF THE X-RAY IN SKIAGRAPHY.

CHAPTER I.

INTRODUCTION.

THE static machine plays such an important part in the production of the Roentgen ray that a treatise on the employment of static electricity is incomplete which does not include the subject of its various applications.

To consider the X-ray from the standpoint of but one source of energy, however, would be narrow and prejudicial to the proper treatment of the subject. It is the purpose of the writer, therefore, to show the advantages of the several types of apparatus employed.

So much diversity of opinion exists with reference to the efficiency of the various kinds of static machines and coils that it will not be possible in a work of the scope of this volume to consider, except in a general way, the merits and shortcomings of apparatus.

The writer's intention is to condemn none, but to encourage such improvement in apparatus as will make the physician's armamentarium replete with such appliances as will be efficient.

Skiagraphy has already passed through two epochs of its history since the discovery of the X-ray by Professor Roentgen. The first epoch of discovery and publication was one of unbounded enthusiasm, during which wonderful tales were told of the new force and its possibilities. The expectations of the public and profession were raised to the highest plane, only to be followed by the second epoch of disappointment and condemnation. During the first epoch, unfamiliarity with the

characteristics and actions of the X-ray was the cause of many accidents and disappointing results from its employment.

Accidents which occurred during the first two epochs in the form of severe X-ray burns discouraged many early operators and caused a feeling of suspicion as to the expediency of its employment. Idiosyncrasy was given a very prominent place which later investigation has shown to exist only in a moderate degree, burns having been oftener produced from overlong or too frequent exposures in the hands of those who were unfamiliar with its actions.

Surgeons began to doubt its value in localizing foreign bodies, as they had often failed to find the object in the spot indicated on the skiagraph. Up to this time it had not been appreciated that the relative position of a body with reference to the anti-cathode and the sensitized plate often produced a deceptive location of the shadow of the image upon the skiagraph. The causes of distortion have since become better understood, and by cautious methods localization is made more accurate.

During the second epoch, the therapeutic uses of the X-ray began to be studied by a few early observers, but received no particular attention or credence until within the last three years.

The third, or present epoch, is the one of technical, scientific study, and a better appreciation of the limitations of an agent supposed at first to possess more remarkable qualities. There is also with the fuller realization of possibilities an accomplishment of results which tends to restore confidence and again bring the measure into universal favor. It is the epoch of realization and substantial recognition of this valuable diagnostic and therapeutic agent.

There are still many questions calling for more careful study of the scientific application of the X-ray as a diagnostic means. At the present time, however, its use in accurately locating foreign bodies, diagnosing calculi, fractures, and various visceral conditions has become too certain to leave a doubt as to its value. What is now required is greater skill in its application, which cannot be expected of the general practitioner

or student of medicine who has not received the proper technical instruction in its different applications. The subject is a progressive one, and in the near future many improvements will be made in appliances for more definite and precise localization, rapidity in making exposures, and development of the sensitized plate, as well as other features which will tend to perfect the methods in present use.

CHAPTER II.

GENERAL CONSIDERATIONS OF THE ROENTGEN RAY.

SINCE Professor Roentgen announced his discovery of the X-ray, made on November 8, 1895, the vocabulary has been enriched by the addition of terms applicable to the new art.

The names given to the process of making pictures of the shadows of the invisible in common use are radiography from the Latin *radius*, or ray, and *grapho*, to write, ray-writing, or the writing of a ray, and skiagraphy from the Greek *skia*, a shadow, and *grapho*, to write, shadow-writing, or the writing of a shadow.

Both are in common use by good authorities. While some have taken partisan ground in favor of the former name, equally good authorities have adopted the latter. The terms are both philologically correct and are interchangeable. From the same derivations we have the words *radiograph* and *skiagraph* (also called *skiagram*)—applied to the print from the impression on the plate which has been exposed and developed. *Stereo-skiagraphy* and *stereo-radiography* (also known as *stereoscopic radiography*) are expressions which refer to the stereoscopic observations of the subject. *Skiascopy* is the name applied to examination of the chest with screen or fluoroscope. *Radiotherapy* is aptly applied to the use of the X-ray in the treatment of disease. When Professor Roentgen (pronounced Runtken) called the peculiar radiance *the X-ray* he fixed upon it a name which is expressive of its to be discovered features—the (X) unknown ray. Here, as with scientific discoveries generally, the name Roentgen has become inseparably a feature of the nomenclature, and the expression *Roentgen ray* is interchangeable with the name adopted by the discoverer.

The term *cathode stream* refers to the discharges from the

concaved cathode terminal in the X-ray tube. The *anode* of the X-ray tube is naturally the terminal to which the positive connection is made. The *anti-cathode* is the surface upon which the cathode discharge is focused, and may be a platinum anode placed in the center of the tube of the Jackson type or the glass projection of the glass side of the original Crookes tubes, Fig. 7, or tubes provided with a projection and water-cooling device as the jacketed cavity tube, Fig. 10, Sec. III. The *anti-cathode* has also been called the *target* by various writers.

The vacuum of the tube has given rise to different expressions defining that characteristic. The terms *high-vacuum, low-vacuum,* and *medium-vacuum* will express this condition of the tube.

Various writers have adopted the terms *hard, soft,* and *medium hard* to indicate the relative vacuum of X-ray tubes. Such unfortunate terms and applications will creep into the nomenclature with all growing scientific subjects.

Source of the X-ray.—This peculiar radiance is produced by an electrical discharge of high voltage through a sufficiently exhausted Crookes tube. The rays are invisible, and the property of penetration may be due to their being longitudinal vibrations of great intensity.

The physical characteristics of the X-rays are as follows: (1) They penetrate many substances opaque to other rays. (2) They are refracted * when passing from one medium to another of different density. (3) They are but slightly reflected and are absorbed by substances which they do not penetrate. (4) They affect photographic dry plates as do light rays. (5) They produce fluoroscence of many substances, notably platino-barium cyanide, willemite, tungstate of calcium, rock salt, fluorspar, and glass. This property is noticeable also in the greenish fluorescence of the glass of all tubes.

The penetrating qualities of the rays relative to different substances depend but partially upon any law of specific gravity, atomic weight, or density (note Figs. 1 and 2, and description). Organic substances, except bone, which is largely calcium, are generally transparent to the rays. Wood fiber, mus-

* Recent investigations have demonstrated that they are refracted.

cle, and other vegetable and animal matter are to a variable extent penetrated, the density and thickness of the object lessening the distinctness of the fluorescence upon the screen or

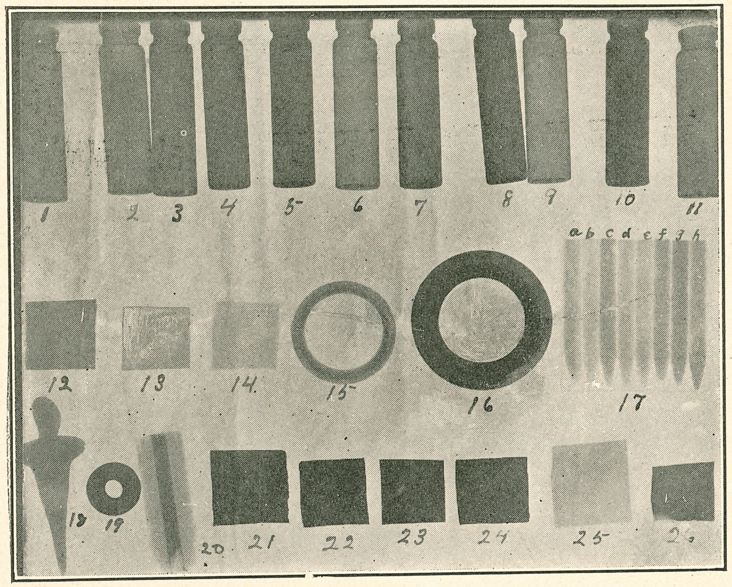


Fig. 1.—Showing the Relative Penetration by the X-Ray of Different Metals, Colored Solutions, and Other Substances; Indicating that no Law of Specific Gravity or Density Governs Transmission.

1, Vial of water; 2, air-slacked lime in bottle; 3, empty bottle; 4, thionin staining fluid; 5, hematoxylin (stain); 6, aurantia (stain); 7, methyl blue (stain): 8, indolin (stain); 9, sol. cocaine; 10, chloroform; 11, salt solution; 12, Garlock packing, 1/16 in.; 13, oil cloth; 14, linoleum: 15, ring of vulcanite; 16, soft rubber ring; 17, box of crayons: *a*, red; *b*, indigo; *c*, yellow; *d*, brown; *e*, green; *f*, white; *g*, orange; *h*, black; 18, glass dropper; 19. nickel ring; 20, stick of carbon with iron core; 21, sheet lead (32 gauge); 22, block tin (22 gauge); 23, Crookes composition (22 gauge); 24, Crookes composition (32 gauge); 25, aluminum (22 gauge); 26, Garlock packing.

sensitized plate. Blood and pus intercept the rays to such a degree that congested regions, abscesses, pus cavities, and empyema are demonstrable. Of the metals, aluminum is relatively transparent.

The photographic dry plates, films, or sensitized paper are affected by the X-ray as by light, which manifests their chemical action. They penetrate paper, which ordinary sunlight does not, making skiagraphy an easy process. No camera or screen is required. The subject or object to be skiagraphed

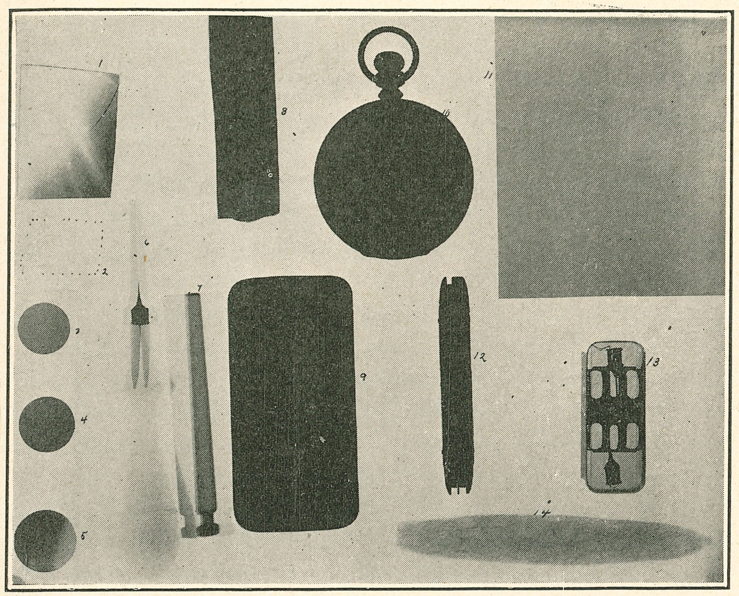


Fig. 2.—From a Skiagraph Made by Dr. A. C. Geyser, Showing Varying Transmissions of the X-Ray of Different Substances.

1, Piece of tin-foil; 2, piece of wood, ¼ inch thick; 3, ten-cent piece; 4, one-cent piece; 5, five-cent nickel piece; 6, wooden instrument handle: 7, glass vial; 8, piece of rubber composition used for protection; 9, brass hypodermic case; 10, watch; 11, developed negative; 12, pocket-knife; 13, aluminum case with hypodermic needles; 14, cigar.

is placed between the enveloped plate and the tube. The radiance is then excited for the required period of time.

Fluorescence is evidenced in a darkened room upon the screen or with the fluoroscope of platino-barium cyanide or tungstate of calcium. It is noteworthy that platino-barium cyanide, which afforded Professor Roentgen the opportunity

of making his accidental discovery, though other substances have been employed for the purpose of fluoroscopic observation, is still preferred. The green color of a tube during radiance is due to the fluorescence of the glass.

The quality of the radiance depends upon the relative conditions and characteristics of the exciting apparatus and the tube.

The consideration of the relative merits of apparatus—static machines and coils—for exciting X-ray tubes; the relative power of penetration of the rays excited under different conditions; the technique necessary to obtain good results under varying circumstances, are all important subjects which will receive special attention in the following chapters.

Dr. Williams of Boston employs a Holtz machine having but six plates, each of which is six feet in diameter. The current from such an apparatus has the possibility of an immense voltage, but the amperage is practically the same as of a Holtz, having the same surface area on a larger number of revolving plates, the voltage depending upon the speed and diameter of the revolving plates, and the amperage upon the aggregate of the surface of the revolving plates.

Dr. Williams would demonstrate that the potential (voltage) is of the greatest importance. On the other hand, others have done equally good work with static machines having from eight to ten revolving plates, thirty inches in diameter. With static machines, however, having from twelve to sixteen thirty-to forty-inch revolving plates, it is possible to shorten the time of exposure, indicating that the amperage thereby increased plays an important part in the element of time, other things being equal. In this experience the writer concurs.

The experience of excellent authorities indicates that good results do not alone depend upon the amperage of the current, but upon the tube and method employed. The amperage, however, does shorten the requisite length of exposure.

The eight- and ten-plate Holtz machine serves so well for therapeutic purposes, as has been shown in the preceding chapters, that it is important to know that excellent results in radiography can be obtained with them in most cases, though at the expense of additional time. It may also be inferred from the results and experience of Dr. Williams that the diameter of the plates and consequent increased volt capacity of the machine is of importance. With the coil apparatus it is difficult, except with a Tesla transformer, to raise the voltage and reduce the amperage to anything that approaches the extremes of proportion of that excited by a powerful static machine.

It is shown by those who make use of the various coils in connection with an ampere meter and controller that the relatively greater amperage shortens the time of exposure, and when used with low-vacuum tubes obtains better both definition and detail. This is done, however, at a greater risk to the tube, always shortening its life, with the added possible danger of puncturing or melting the parts, which is only obviated by the employment of special tubes.

The time is approaching when an accurate consensus of opinion will determine the regulation of amperage and voltage necessary to meet special indications and for general use.

X-rays vary in penetrating power with the vacuum of the tube and the character of the current employed. A high-vacuum tube which requires the full capacity of a powerful exciter to induce a radiance will show the greatest degree of penetration, but will not give detail or contrast. A low-vacuum tube, with which the bones appear dark, and the shading of the tissue of the soft part is discernible, will show contrast and detail if the penetration is sufficient to affect the sensitized plate. Such a tube, when properly energized by large ampere currents, or with a static machine having a suitable method of interruption, is valuable for special work in skiagraphy.

Between the extremes will be found all degrees of variation in tubes, which adapt them to special cases and work to be done. The vacuum of X-ray tubes is a constantly changing factor, because it becomes higher with use. Besides the vacuum of tubes, there are features of variation which are individual in tubes of the same manufacture and which mark a degree of excellence or inferiority often unaccountable—the

thickness and quality of the glass, position, relation, and deflections of the cathode and anti-cathode account in a measure for these variations.

The science is a growing one; but progress to the present time has developed, by its practical utility in diagnosis and therapeutics, a degree of perfection which makes it invaluable to the medical profession.

CHAPTER III.

X-RAY APPARATUS.

THERE are two distinct types of apparatus in common use for producing the X-ray—the static machine and various modifications of the Ruhmkorff coil. The Tesla transformer was formerly considered, but has been superseded by the other types of apparatus.

Static machines are made of three types, which have been considered in Section I., all of which are more or less effective for the purpose under consideration. The same test may be applied for determining the capacity of the machine as was given in the chapter on apparatus in Section I. Another test may be made by employing the spark interrupter (see Fig. 3) on the negative side of the circuit between the tube and the machine, placing in the circuit, at the same time, a tube of low vacuum. For the purpose of this test employ a series interrupter having at least thirty brass balls separated about one-eighth of an inch, and provided with means for increasing or diminishing the number of spark-gaps in the circuit. A machine which will cause a series of sparks in rapid succession to run across the whole line of balls and spark-gaps and a spark-gap of one inch at each interrupter on the discharging end, under favorable conditions, will be efficient for most uses of the X-ray. Of the Holtz class, a machine to produce the above effects will, under most conditions, require ten or twelve revolving plates, at least thirty inches in diameter. Any other type of machine which will produce the same effect is to be relied upon to serve the same purposes. Machines having less capacity, in many instances, serve well for X-ray and therapeutic purposes, if the conditions do not require too great an expenditure of energy, either for the purpose of exciting a high-vacuum tube, or for causing a low-vacuum tube to give a radiance rich in rays.

X-ray coils are of great variety, and differ in efficiency.

The important features of a coil are: (1) The capacity to carry currents of varying amperage, adapting them to special work. (A coil for general purpose work, employing ten- to fifteen-ampere currents, is not an economical coil to use for ordinary uses in radiotherapy and for taking skiagraphs of the less dense structures of the body.) (2) The coil which reduces the amperage in a secondary to the minimum is less destructive of X-ray tubes than that constructed of coarser wire and less windings. Such a coil, however, is more apt to

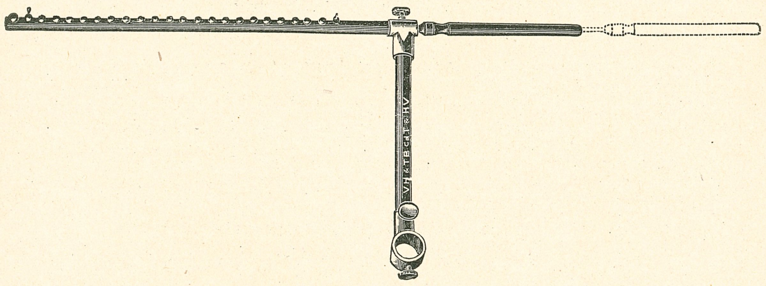


Fig. 3.

break down, or the insulation or wire be destroyed. (3) The coil should be constructed so that it is not apt to break down under the conditions to which it will be subjected. For the production of a high degree of radiation with high-vacuum tubes, the character of insulation in the windings of coils is a matter of great importance. Various means are adopted for making the insulation nearly perfect. The best assurance, however, that a coil will stand the test of endurance, is the willingness of the manufacturer to guarantee it against breaking down. It is needless to say, in view of the experience of the average physician in regard to the principles and methods of employment of such apparatus, that the manufacturer runs an extraordinary risk in making such a guarantee. One, therefore, who so guarantees his apparatus must have confidence in the workmanship and construction of his coil. However, a guarantee is not always an assurance that a given coil will energize a tube to the degree necessary to produce the

same effect that other coils may; nor does the spark capacity signify the quality as to the amperage of the current which it will produce. On general principles, then, it is wise for the physician to obtain a guarantee when possible, and, at the same time, to be assured that the coil he buys is capable of rendering the required service. There is much to be said in favor of

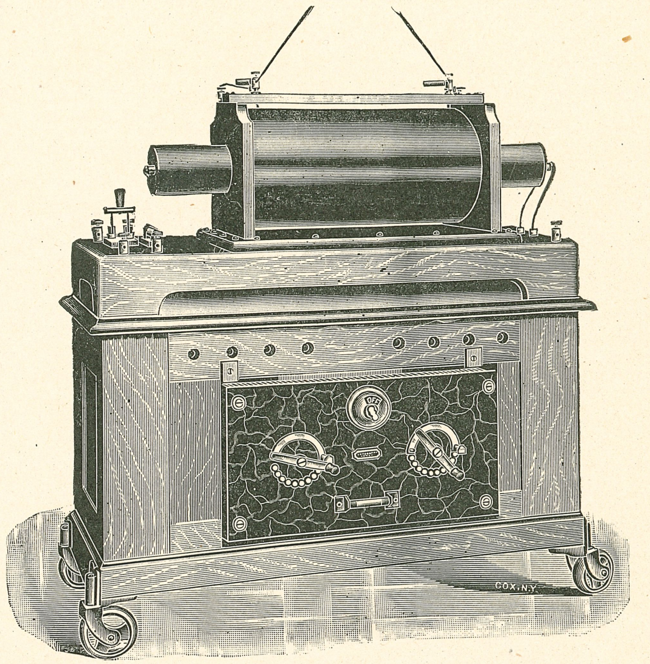


Fig. 4.—Type of X-Ray Coil.

the use of large ampere currents and low-vacuum tubes in connection with skiagraphy, when the apparatus is to be employed for radiographing structures or objects requiring detail, as calculi.

It is in this particular that the coil has an advantage over the static machine. The necessity for discriminating between the several apparatus for special work is becoming better recognized as the science is more fully understood. A coil using a current of from three to five amperes of about one

hundred and ten volts is capable of doing all ordinary therapeutic and X-ray work, as well as radiographing satisfactorily most conditions. It has, however, been demonstrated, as stated above, that a coil best suited to skiagraph the conditions and structures which require detail, such as stone in the kidney or gall bladder, is one which will use a current of seven to fifteen amperes and about one hundred volts from the commercial current, in connection with a low-vacuum tube. This combination will produce a radiance *very* rich in the number of rays, and while the individual rays are less penetrating than the rays from a high-vacuum tube, the great volume of rays compensate and do effect a passage through dense tissues and affect the sensitized plate.

To operate such a coil requires a degree of familiarity with the technique as well as with the operation of tubes with large ampere currents, a familiarity gained only by experience—not alone in using the apparatus, but in developing the X-ray plates, q. v. Those in quest of a suitable coil can easily find one for ordinary service, and there are now many also capable of skiagraphing most difficult conditions.

The writer's experience with coils and static machines has led to the conclusion that for general purposes, excepting the special coils referred to, the efficient static machine is to be preferred for the reasons that it does the work equally well, and for the general practitioner, surgeon, or specialist serves a valuable purpose for therapeutic administrations.

In every otherwise well-equipped physician's office, there should be at least one static machine, having a capacity of doing good therapeutic and skiagraphic X-ray work. If an additional apparatus is needed, for X-ray purposes, and the demand for static administrations is provided for with the apparatus on hand, a coil will occupy less space than another static machine, and not be susceptible in any way to atmospheric influences. Under these conditions a superior coil for skiagraphic purposes will work well, and may, at the same time, serve for a limited degree of therapeutic work, the only disadvantage being the destructive action upon X-ray tubes.

When we compare the relative merits of coils and static

machines there are several points to be taken into consideration, as shown respectively in the parallel columns, as follows:

Advantages.

Static Machines.

1. They are invaluable for therapeutic administrations.

2. They are thoroughly effective and capable of doing as good X-ray work as coils, except the coils which employ powerful currents, and in skilled hands are capable of doing fairly rapid skiagraphy and for locating calculi.

3. They are relatively noiseless, easily adjusted, and not apt to suffer serious damage when in operation.

4. High-vacuum tubes can be excited by them for long periods without serious damage or risk to the apparatus.

5. Tubes last for a much longer time without material deterioration, and are not so apt to be punctured.

6. They do not require an electric current or operation, as hand, water, or other power may be utilized.

Coils.

1. They may be used for some therapeutic purposes in connection with glass vacuum electrodes, with which in conjunction with a properly regulated controller they do valuable service.

2. When properly constructed they are effective and capable of doing better skiagraphy under difficult conditions than other apparatus.

3. Many coils and apparatus are portable, and may be used wherever a proper current is available, or by taking the current from the storage battery of an electric automobile.

4. Coils are not affected by atmospheric conditions.

5. Coils carrying large ampere currents, properly constructed, employed with low-vacuum tubes, are superior to other apparatus for instantaneous skiagraphy, and in skiagraphing tissues easily traversed by high vacuum tubes.

Disadvantages.

Static Machines.

1. They are not portable.
2. They occasionally suffer interference during periods of humidity, which may be obviated as shown in Section I., Chapter III.
3. They are not as capable as other apparatus in skiagraphing calculi and giving detail of tissues easily traversed by the X-ray.

Coils.

1. They are not to be compared in value to the static machine for therapeutic purposes.
2. They are more apt to puncture and otherwise impair the X-ray tubes.
3. Some coils, when subjected to long use, are apt to break down and become otherwise impaired.
4. They are more noisy when employed with many interrupters in common use.
5. The interrupters used in connection with coils are a source of annoyance and more or less constant expense.

Interrupters used with X-ray apparatus, especially with coils, are numerous.

The static interrupters provided with all machines are so arranged as to lengthen or shorten a secondary spark-gap on both the negative and positive sides of the machine. They are invaluable for inducing an increased bombardment of discharge from either or both sides through the X-ray tubes, thereby varying the intensity of the radiation. These may be supplemented by series interrupters, arranged on either or both sides of the apparatus.

The series interrupters are constructed, having a number of small balls (thirty to fifty), separated about one-quarter of an inch from each other and secured to some non-conducting material, and provided with a sliding rod which may be moved in either direction, increasing or diminishing the number of spark-gaps in the circuit. The insulating material employed in the

construction of these interrupters should be of some material which is an absolute non-conductor. Hard rubber is apt to become heated and carbonized to the extent that it ceases to be a non-conductor. Mica, with a combination of shellac, or glass,

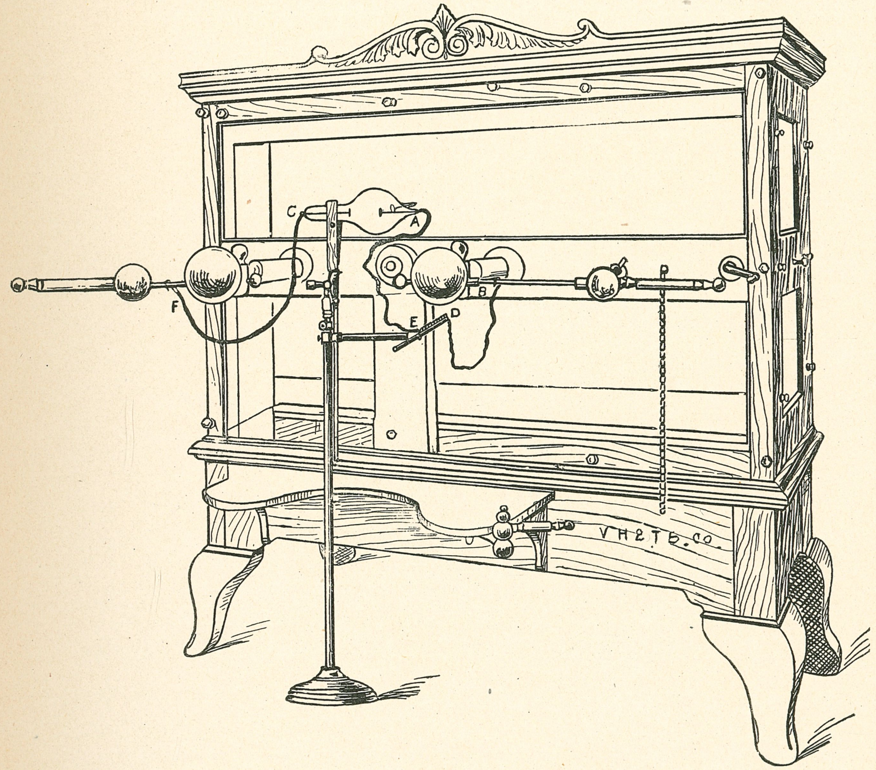


Fig. 5.—Files Interrupter in Circuit.

is the best substance of which these interrupters may be constructed. The Files interrupter, shown in Figs. 3 and 5, is made of mica, and is a practical apparatus for the purpose.

The coil interrupters are the *bête noir* of the X-ray workers. Many varieties have been made, including mechanical, electrolytic, and mercury jet.

A practical interrupter must be both rapid and convenient

of adjustment. The break-wheel interrupter, provided with a blowing device for extinguishing the sparks, was one of the earlier types of interrupters. Later the Wehnelt electrolytic interrupter came into general use and is employed.

The Willyoung improved Wehnelt interrupter shown in Fig. 6, for direct or alternating current, is provided with an

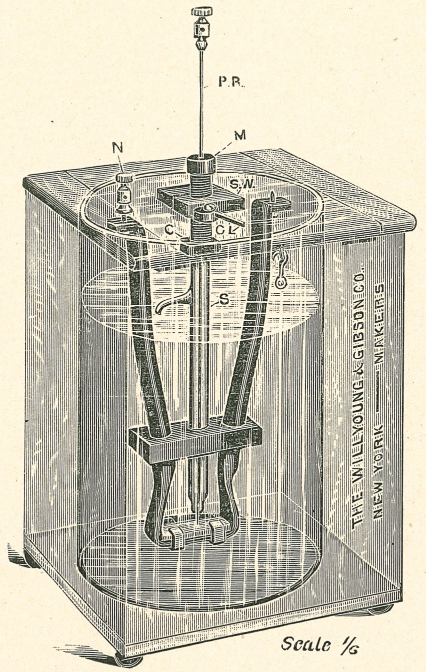


Fig. 6.

automatic feed by means of which the active electrode always rests against a glass stop, descending by gravity as it is consumed. To obviate overheating or make the heating much slower, extra large jars are employed with this interrupter. The electrolytic interrupters are invaluable for rapid radiography because they permit the passage of a large volume of current through the tube.

Various types of mechanical interrupters are in common use,

and, though permitting less rapid interruptions, serve a practical purpose. The objection to them, however, is that they require metal terminals which, if not of platinum, are rapidly destroyed, and eventually the platinum tips are also used up.

The mercury-jet interrupter, one of the most recent and best types, has the disadvantage that the oxidation of the mercury

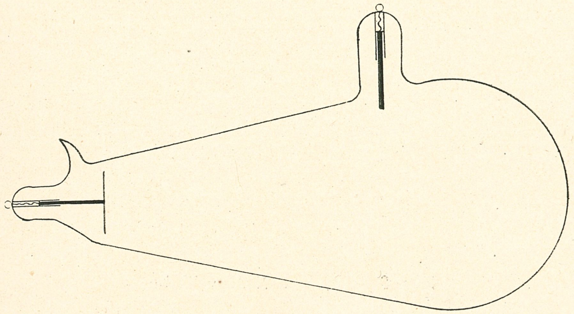


Fig. 7.—Crookes Tube.

necessitates frequent cleaning. A motor is necessary for operating this type of interrupter. Another coil is provided with parallel disks, which can be regulated in distance to the current employed, giving a rapid spark interruption. The disk is provided with a vessel filled with water placed over the plate for cooling. The disks become oxidized, requiring frequent cleaning, or an intermittent, irregular interruption occurs. None of these interrupters can be considered perfect, but they practically meet the requirement, and, with requisite care and attention to details, answer the purpose.

Of Crookes tubes, the earliest type was described by Sir William Crookes before the British Medical Association, 1879, a cut of which is shown in Fig. 7. These tubes were constructed with the cathode of aluminum, having a plane, not concave, surface, as in the tubes now in general use. With these tubes, the glass side of the tube opposite the cathode was the anti-cathode, from which the rays were emitted, the anodal connection being placed on one side of the tube. Such tubes

when emitting rays, except the tube is of very low vacuum, will soon heat and puncture the glass, making them impracticable for therapeutic purposes or for diagnosis.

Since the vacuum of tubes becomes constantly higher, these tubes were necessarily short-lived. The cathode having a plane surface, the cathode rays were also diffused, not focused,

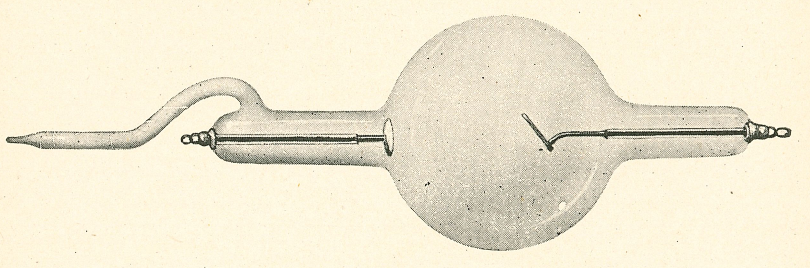


Fig. 8.—Modern X-Ray Tube.

as in tubes which are now constructed having the cathode concave on the side facing the anti-cathode.

To Mr. Herbert Jackson, an English physicist, president of the British Roentgen Ray Society, belongs the credit of having suggested the first practical method of obtaining an efficient radiation from what is now known as the "X-ray tube." He had a tube constructed in which the anodal terminal was placed in the center of the globe, and provided with a small platinum plate, placed at an angle of about forty-five degrees with the long axis of the tube. Opposite this was the cathode, which was concave, and placed at the distance and angle at which the cathode rays would focus upon the anti-cathode at the center. In this type of tube the anti-cathode is the anode. By this arrangement the volume of the rays concentrated upon the anti-cathode was reflected forward in lines radiating from its surface—the plane of the platinum plate dividing the tube into a dark and radiating field, at the same time projecting the rays at a convenient angle for practical use. (See Fig. 8.)

In the earlier type of tubes, the disposition to a constantly increasing vacuum was not appreciated, and the bulbs were

made too small, as shown in the accompanying cut (Fig. 9). Experience has developed many practical features in the construction of X-ray tubes. The bulbs have been made larger, and the tubes provided with various means of regulating the vacuum. It is necessary to have the platinum anode made heavy enough to guard against its destruction by melting. Another method of preventing the destruction of the anti-cathode by powerful coils is a water-cooling device, by which a stream of water, pouring in and out, is constantly in proximity to its metal parts. It has been impossible until recently to so construct a tube of this type that the water would come

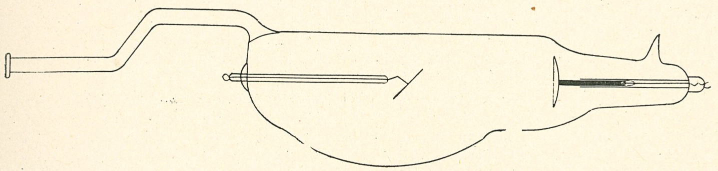


Fig. 9.—Early Type of X-Ray Tube.

in contact with the metal, a glass septum having been necessary. Glass, being a poor conductor, has rendered these tubes impracticable. Tubes have lately been constructed, however, in which the water will come in direct contact with the metal. Water cooling tubes are of particular value for use with coils. For general employment with the static machine, there are many efficient tubes on the market, notably the type of tube shown in the accompanying cut, Fig. 8. There are various types of imported and domestic tubes which are practical and satisfactory. The German and the English tubes, constructed with an adjunct to the anti-cathode, of which a type is shown in Fig. 11, are durable and practical tubes. Many devices have been suggested for regulating the vacuum of the tube. Various salts, rich in oxygen, as oxide of manganese, or chlorate of potash, which may be decomposed upon the passage of an electrical discharge, are used, thereby increasing the volume of gas within the tube, thus lowering the vacuum.

A new adjustable tube shown in Fig. 10 will be found invaluable to X-ray workers.

It is found by every operator with X-ray tubes that just when a tube begins to do the best work the vacuum suddenly becomes too high, the current refusing to go through it, or only after requiring a long and tedious coaxing. This is caused by the destruction of the small amount of air which is necessary to permit the passage of the current. With this form of regulator, the vacuum may be readily lowered. By unscrewing the metal cap, and immediately screwing it up again, an air passage is opened and a small amount of air is added and the tube is again as good as new. This may be done an indefinite number of times and the quality of the tube be as often restored.

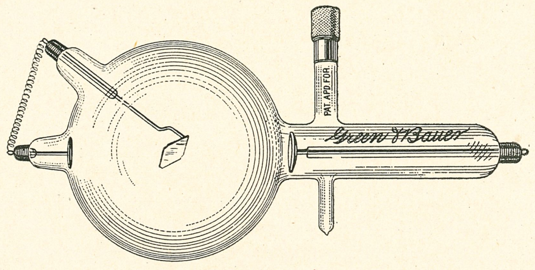


Fig 10.—A Type of Adjustable Tube and Cut of Regulating Device.

Another important feature of the tube is that a very thick pure platinum anti-cathode is used, allowing no possibility of burning through. Pure platinum gives so much better results than the plated anti-cathode so commonly used in foreign tubes that this is a step in the right direction. The tube shown is designed for use with the static machines. It is claimed by the manufacturers that for radiography this tube has no equal in bringing out the detail of the soft tissues, muscles, etc., for the reason, which must appeal to all operators, that a tube that can be kept low has the proper qualities for giving best detail on the negative. A tube can only be retained at a low vacuum by replenishing the air supply. This is accomplished by their tube and at less cost for the tube in the first place than any other. These tubes are constructed in accord

with the writer's oft-repeated plea for solid platinum anti-cathodes.

The writer has found, in connection with his X-ray work, that baking the tubes is a practical method. If care is taken not to permit a tube to become too high, but to lower it as soon as it shows a four- to six-inch spark resistance, the tube will rarely puncture.

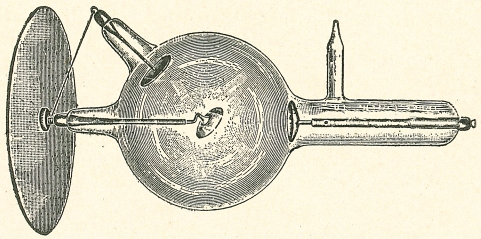


Fig. 11.—A German Tube.

Baking an X-ray tube, or submitting it to a high temperature for a necessary period of time, will lower the vacuum. This may be effected by the glass becoming sufficiently porous under high temperature to permit the passage of air into the tube. The process is one which requires but little practice to successfully accomplish the result. The time necessary will depend upon the degree of temperature employed, and until familiar with the action upon the tube, it is well to begin by continuing the process in a very hot oven for not more than five minutes.

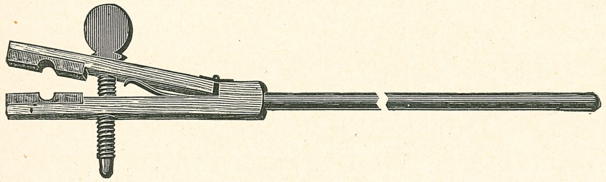


Fig. 12.—Tube Clamp.

The writer places the tube upon a piece of asbestos in the

lower oven of a "Perfect" gas range, burning a full blue flame for five or ten minutes. Under this treatment the vacuum of some tubes will be lowered to such an extent that a fluorescence will not be produced unless the ball interrupter is employed. With that apparatus, however, it is possible to work a tube thus lowered and obtain practical results

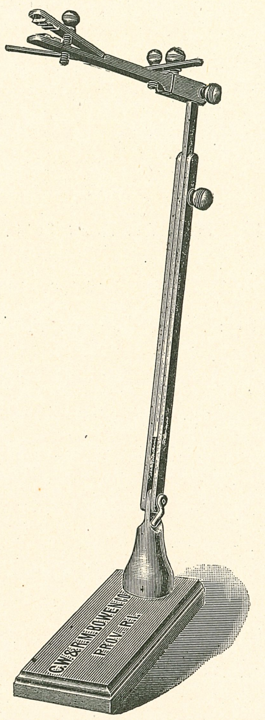


Fig. 13.—Tube Holder.

in the treatment of superficial conditions, as acne or lupus, until the vacuum is gradually raised,

Experience in baking a given tube will govern the length of time best calculated to obtain the desired vacuum. It has been said by some that tubes thus treated soon become high again. This, however, is not in accordance with the writer's experience. If care is taken to place the tube upon a piece of

asbestos, or in a pan of earth or ashes, so that the glass does not touch the metal of the oven, the danger of injuring the tube by this process will be avoided. Various special tubes have been devised for therapeutic use, which will be described in the following section.

Tube stands, or holders, of many designs are employed. Every manufacturer of coils and static machines provides a different design. The essential features are: (1) A provision

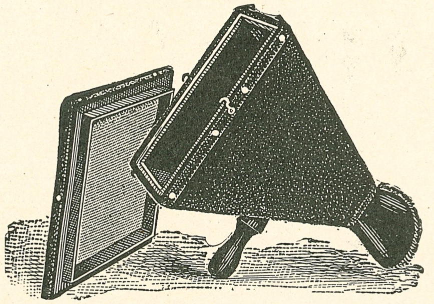


Fig. 14.—Fluoroscope.

by which the tubes may be placed in any desired position, (2) a substantial wooden or iron base which will not be easily overturned, (3) an upright standard, preferably of wood, with an extension that may be raised or lowered and provided with movable socket or thumb-screw for securing the tube-clamp. The staff of the tube-clamp (see Fig. 12) should be at least two and a half to three feet in length, and held in position by a thumb-screw. The clutch, or clamp, for holding the tube should always be of wood, and so constructed that it may be quickly adjusted and opened wide enough (at least two inches) to receive tubes of any size. A stand should also be provided with a means for holding the cords connecting the tube with the machine away from the standard and sides of the tube. It is also desirable that above the base the upright standard should be of wood. While this is not absolutely necessary, it prevents the escape of current from the cords, a matter of importance when operating high-vacuum tubes. (See Fig. 13.)

A fluoroscope is an apparatus consisting of a closed chamber, provided with an opening surrounded with a fur border to exclude the light when the face is pressed against it for the purpose of observing the opposite side, which is provided with a cardboard cover, coated on the inner side with crystals of

Fig. 15.—Fluoroscopic Screen.

platino-barium cyanide or tungstate of calcium, which fluoresce brightly when exposed to the X-rays. (See Fig. 14.)

A pane of lead glass placed on the inside of the fluoroscope over the screen will protect the eyes from the action of the rays.

Screens of various sizes are made of the same material as the fluoroscope, the pasteboard being secured to a frame (see Fig. 15). They are usually employed for examining the chest in a dark room. The convenient size for practical use is eighteen by twenty-two inches. These screens and fluoroscopes are expensive on account of the material and process of manufacture, costing about 25 cents per square inch.

CHAPTER IV.

THE METHOD OF MAKING THE SKIAGRAPH AND DEPENDENT FEATURES.

THE process of making the skiagraph is simple, but requires experience to perfect the details of exposure and skill in the process of developing the sensitized plate.

Familiarity with the characteristics of X-ray tubes and their adaptation to varying conditions is an important feature in skiagraphy and requires particular attention.

The individuality of X-ray tubes: when it is appreciated that tubes vary greatly in the quality of radiance emitted, the selection of a tube becomes a subject of no small importance to the radiographer.

Features of construction which are capable of producing variations in tubes will depend upon (1) the kind of apparatus for which they are designed, (2) the quality, thickness, and size of the glass globe of the tube, (3) the quality of the metal parts of the tube and their relative position, form, and size, (4) vacuum of the tube.

(1) **The apparatus** with which a tube is to be employed will determine different features in its construction. A tube which is to be used with a twelve- to fifteen-inch coil, capable of carrying a current of twelve to fifteen amperes, will require an anticathode either manufactured of a thick block of platinum or provided with a water-cooling device to protect it from melting during radiation. Tubes for such coils should also be provided with some practical means of reducing the vacuum, because they may become high during one prolonged exposure. Those that are used in connection with the static machines and the smaller types of coils will vary in these requirements in accordance with the individual characteristics of the apparatus. Tubes used with static machines having

twelve to twenty revolving plates will require heavier anti-cathodes than those used with apparatus of small capacity.

(2) **The glass** of which X-ray tubes are constructed should be free from metal, especially lead—the lead-glass bulbs transmitting but few of the rays. When it is considered that all glass but slightly transmits the Roentgen ray, it can but be appreciated that the glass should be as thin as possible consistent with the necessary strength of the tube. The glass in no case should be thicker than 1-60 of an inch, and should be constructed in the form of a globe, because that form will best

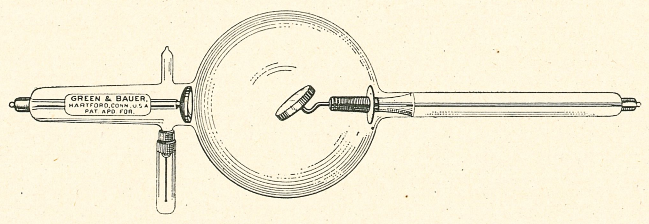


Fig. 16.—X-Ray Tube, Showing Heavy Metal Anti-Cathode.

withstand the atmospheric pressure. A practical-sized globe is one six to eight inches in diameter, the vacuum of the smaller ones requiring more constant attention for regulation, and the gases also becoming so hot as to lower the internal resistance, and, consequently, the character of the radiations.

(3) **The metal parts of the X-ray tube** are preferably of platinum and aluminum, these metals being but slightly acted upon by the electric discharges. The cathode, which is uniformly of aluminum and properly concaved, should be so placed that the cathode rays will be focused upon the center of the anti-cathode. The anti-cathode, which in most tubes is the anodal terminal, should be of pure platinum. The tubes constructed of a single very thin piece of platinum are short-lived. The anti-cathode is soon perforated, thereby permitting the cathode discharge to pass through. These thin anti-cathodes also become distorted into various shapes when heated, and ultimately fail to properly project the rays. In a few instances in the writer's experience, the cathode rays have been projected against the sides of tubes and have resulted in puncture.

Tubes constructed with this type of anti-cathode are of no practical utility, except in connection with small-sized static machines, the larger machine and small coils soon rendering them useless, either by melting, puncturing, or distorting them. The best general-purpose tube, though costing more, is one provided with a solid platinum anti-cathode, at least 1-32 of an inch in thickness. The disposition to construct tubes with cheap anti-cathodes is against the interest of the radiographer. When the first cost of the tube is taken into account, and the fact that platinum so employed is not destroyed, it is advisable that the radiographer insist upon this feature of his tube. The old platinum will pay the difference of the purchase price of the next tube.

With a properly placed cathode, the anti-cathode will first become red at the center, because the rays are focused to that point.

(4) **The vacuum of the X-ray tube** is an important subject for study in connection with radiography and radiotherapy.

The terms *hard* and *soft*, as applied to Crookes tubes, are ill-chosen, and the writer thinks bad form when applied to the degree of vacuum. Better expressions are the terms which directly indicate the condition, *high* and *low* vacuum. The degree of vacuum of an X-ray tube is best determined by the spark resistance of the tube with the apparatus with which it is to be employed, bearing in mind that the length of the spark resistance varies to a slight degree with the amperage of the current employed, and the temperature within the tube.

In other words, a tube with which the spark begins to cease to discharge at the spark-gap, when the balls of the discharging-rods are separated for one inch with a static machine having eight revolving plates, will radiate with a slightly shorter spark-gap when put in the circuit of a machine having twelve revolving plates. While, therefore, the spark-gap is the best means of determining the degree of vacuum of the tube, it will be seen to be but relatively exact.

The spark-gap, either with coils or static machines, will then best serve as a means for determining the degree of vacuum of tubes. Other means, however, which will indicate

the quality of the X-rays, either a chemical device, or one which will show varying degrees of penetration, will be welcomed, as a more accurate guide in this important matter. Such a system should conform to tubes employed with all types of apparatus. Efforts are being made in this direction, but as yet no accurate measure known to the writer has been devised.

The resistance within the vacuum tube varies with the temperature; in other words, when a tube has been excited until the anodal plate has been heated for a time sufficient to raise the temperature of the ether and gases within the tube, the spark resistance of the tube becomes perceptibly lowered. With small tubes in heavy coil circuits this is often marked. The same thing may be accomplished during the winter months by thoroughly warming the tube, which shows conclusively that the lowering of the temperature of the ether and gases increases the internal resistance of the tube, and *vice versa*. This fact gave rise to the term of "working up the tube," meaning inducing a high-vacuum tube to produce a practical degree of radiation. It will be observed, under these conditions, that when a high-vacuum tube at first excited induces a certain radiation not rich in X-rays, upon the tube becoming heated the volume of the radiance is greatly increased. In a tube in which it is impossible to induce heat sufficient to cause the anticathode to become red, either because the vacuum is too high or too low (it will occur in either case), some other means must be invoked to increase the temperature within the tube in order to work it up to a practical degree of radiation. This may be done by heating the exterior of the tube with an alcohol lamp, or by otherwise heating the tube, or, in case of a low-vacuum tube, by connecting in the circuit the series-ball interrupter, thereby increasing the intensity of the bombardment of discharges within the tube. **The volume of radiation,** under such circumstances, depends upon the intensity of the bombardment or sudden impulse of current that is thrown into the tube and the relative quantity of the current; in other words, a static current from an eight-plate machine having a series-ball interrupter, provided with a regulating controller, as shown in Fig. 5, placed upon one side, preferably the negative side of the

circuit, will increase the volume of radiance in a low-vacuum tube by the increase of each spark-gap of the series. The capacity of the machine, however, will be marked by the number of spark-gaps across which the spark will pass under these conditions. With a twelve-plate machine, therefore, the number of spark-gaps will be increased and the volume of radiance proportionately, the increased amperage of the additional plates of the twelve-plate machine adding to the possibility of increasing the volume of radiance.

The relation of the amperage to the volume of radiance is evidenced by the increased efficiency of a given tube when excited within the circuit of a static machine of small capacity and then in a coil circuit.

The intensity or penetrating quality of individual X-rays will depend upon the vacuum or internal resistance of the tube. The rays excited by passing a powerful current through an X-ray tube of high vacuum are of greater wave length and consequent intensity than when the same degree of intensity is employed in a low-vacuum tube, using a current of greater amperage or a multiple spark interrupter. At the same time, the image produced upon the fluoroscope or screen may appear to fluoresce the same.

When a fluoroscope is used in connection with tubes of different vacuum and under different degrees of energy, it is, therefore, often difficult to determine the two features of radiance, intensity and volume, as indicated by different X-ray tubes under different degrees of electrical discharge upon the screen.

The above observation is one of interest and value both to the radiographer and the radiotherapist. A degree of volume which will give a clear penetration on account of the great number of radiations will produce a skiagraph giving details of the structures less penetrable by the X-ray, while a tube producing rays of great intensity will give a better definition or outline of the bony structures and other objects less penetrable by the X-ray. In radiotherapy, the radiance of great volume is productive of the greatest local effect upon superficial tissues and capable of affecting deep tissues as well, but in a

different manner than the X-rays generated through a tube of high vacuum, as is shown in the subsequent chapters on radiotherapy.

The sensitized plates employed in connection with radiography and skiagraphy are the same to the present time as those employed in ordinary photography. Several manufacturers have produced plates which they have designated as special X-ray plates. In the writer's experience, however, for taking skiagraphs of the smaller parts of the body, the ordinary cheap plates will answer the purpose as well. When making a skiagraph of the trunk, however, where detail is the object, an extra-sensitive plate, having a double coating, may be preferred.

The care of the sensitized plates used in connection with the X-ray apparatus calls for particular attention. Such plates must be kept at a distance from the radiating tube or be otherwise protected, as they will become useless from fogging. They may be kept in a metallic box in a closet, in the safe, or upon the floor above the room where the X-ray is employed. Plates have frequently been fogged in closets and desks twenty feet away from the radiating tube. The plates should, as a rule, be kept in the original package until used. This, however, is not imperative, but experience has taught that plates kept a long time in their envelopes, as was the original custom, become less sensitive than those which are recently placed in the envelopes.

Preparation of X-ray plates, putting them in the envelopes ready for use, should be done in a dark room, and it is the writer's custom to observe the following rules: (1) Take the sensitized plate from the box with the film side up;—which is to be discerned by the feeling, the glass side being smoother than the film. (2) Draw the dark-colored envelope over the plate, the side with the folder at one end being uppermost. (3) Close the folder, keeping the plate in the same position. (4) Draw over the first envelope from the folder end, the yellow envelope with the folder also upward. When closed, the plain side of the envelope will always be next to the sensitized side of the plate.

If this rule is uniformly observed the radiographer will always know the film side of his plate, which should be turned towards the tube when the exposure is being made. The plate should never be brought into the room while the tube is actively radiating.

Sensitized paper will often be found convenient as a substitute for the sensitized plate, especially so when it is necessary to prepare a skiagraph for immediate demonstration as is often demanded in court cases. The ordinary bromide paper or an extra-sensitized printing out paper will answer the purpose. The paper should be inclosed in an envelope the same as plates, and if it is desired to have more than one copy, several sheets may be put in the same envelope. The paper is developed in the same manner or by the special developer best adapted, which can be produced from any photographic supply-house. The skiagraph, when paper is used, will be a positive, which is another advantage in using it.

The bony parts or parts less penetrated by the rays will appear white, as they do upon the sensitized plate, and not dark as in the print from the plate. When using sensitized paper, exposures should be made for about twice the length of time employed in making the skiagraph upon the sensitized plate. The accompanying cut will show the appearance of the skiagraph when taken in this manner.

When the skiagraph upon sensitized paper has been developed, it may be immediately mounted upon the cardboard backing. This advantage, and the fact that the print is a correct representation of the parts and not a negative, are two valuable features of its employment.

The process of making a skiagraph includes several significant steps if the result is to be satisfactory. Before arranging the patient and apparatus for making the exposure, it is always best to select the tube to be used and test it with a fluoroscope, to be certain that the apparatus and tube are in order.

I. Posture the subject in the position which will best show the object sought. It will often be well to make a fluoroscopic examination before placing the object in position. If one of

the extremities of the body is the object, it will rarely be necessary to place the patient in a recumbent position. In other cases, however, a table should be provided, which will permit

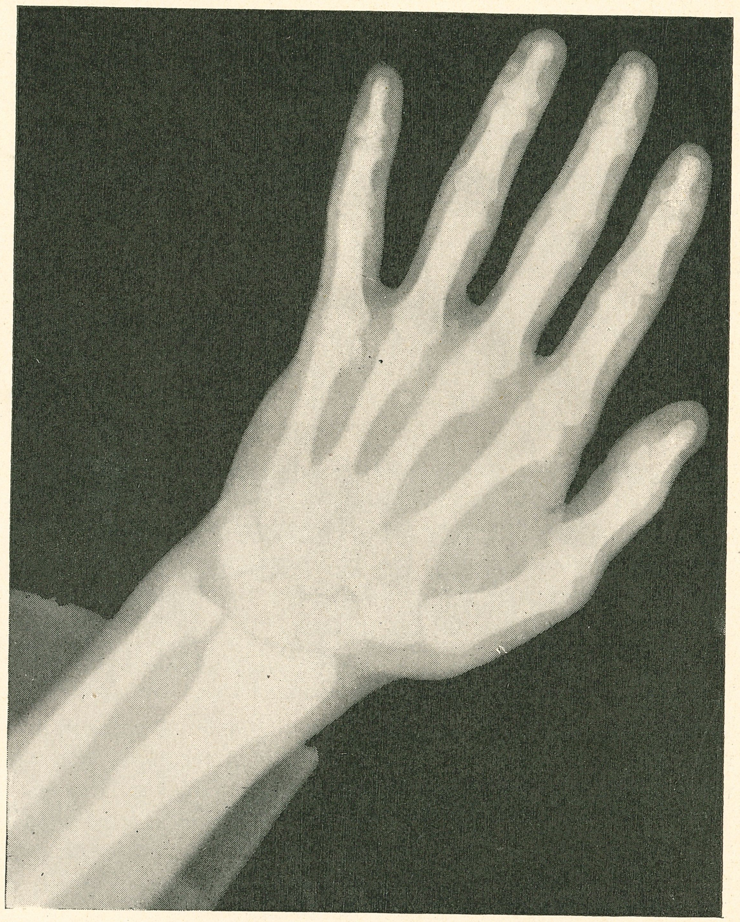


Fig. 17.—Skiagraph Taken upon Sensitized Paper.

the patient to rest in a comfortable position during the exposure. It is not desirable to undertake an exposure for a skiagraph of the trunk with the patient in a sitting posture, except

for good reasons, as in cases of pleurisy with effusion, when it is done to show the level of the fluid in the chest cavity.

When taking an abdominal skiagraph, it is always desirable to place the patient in a position in which the object to be localized shall lie nearest the sensitized plate.

II. Place the sensitized plate beneath the object in a position which shall show the part in good relation to the plate and when possible, except when locating a foreign body, place the corresponding part of the opposite side upon the plate for the purpose of comparison.

A sheet of metal through which the rays will not be transmitted should be placed beneath the sensitized plate to prevent the possibility of the shadows of objects upon the opposite side appearing on the skiagraph, as frequently happens when this precaution is not taken.

III. The choice of the tube will depend upon the object to be skiagraphed. When it is sought to determine the presence of a foreign body which the rays will not traverse, as a leaden bullet, or the condition of the bony structures, a high-vacuum tube will always best meet the requirements. A low-vacuum tube, however, given a longer exposure and energized to a degree that will give a light shadow upon the fluoroscopic screen, will give satisfactory results with the extremities. When, however, a skiagraph of the pelvis, knee, or thigh is taken with a static machine, a high-vacuum tube of four- to eight-inch spark resistance should always be chosen. When detail or a skiagraphic image of an object easily traversed by the Roentgen ray, as calculi, is sought, or even a hip joint when a proper coil is employed, a low tube should be selected, preferably one of not more than one-inch spark resistance, and the tube energized to the maximum capacity of the apparatus employed, making use in such cases, with the static machine, of a series spark-gap interrupter.

IV. The adjustment of the tube requires technical consideration if the best results are to be obtained.

Distortion too often arises from failure to recognize the conditions of the radiation of the X-ray. The employment of the sensitized plate in connection with the process of skiag-

raphy possibly leads to a confused idea, from its association with photography. It must be borne in mind that the image upon the sensitized plate is as if the shadow of an object in the sunlight had made a fixed impression upon a plane surface, not through a focusing lens, with which the image is always reversed. In the latter case the print from the negative produces a second impression upon the sensitized paper with the objects in their normal relation. The reverse is true of the skiagraph: the shadow casts an image upon the sensitized plate of the parts in their normal relation, and the print made upon the sensitized paper reverses the relation of the object, the

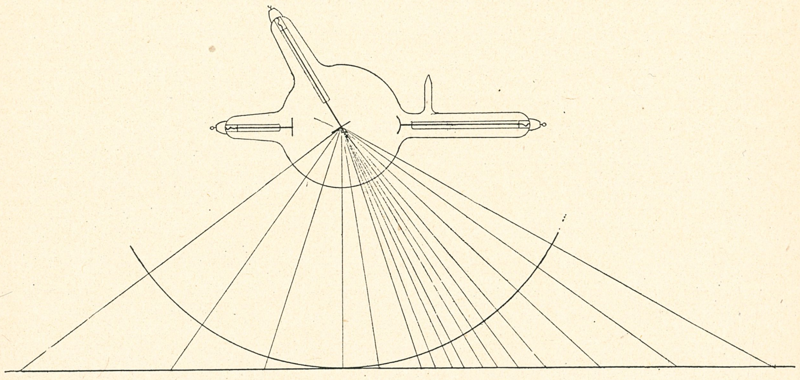


Fig. 18.—Showing Radio-active Field and Occasion for Distortion.

right hand or right side of the body always appearing as the left upon the printed skiagraph.

The sun casts a shadow obliquely or directly upon a background, according as it is placed, relatively before the background. It is the same with the skiagraph: the position of the anti-cathode—the body from which the rays are projected—determines the position of the shadow upon the sensitized plate which will be directly opposite or obliquely placed, according to their relative positions. The rays projected upon a plane surface will in all cases produce a relative degree of distortion, from the fact that the outer rays, making the margin of the skiagraph, are more oblique than the central rays, projected perpendicularly upon the sensitized plate.

This may be illustrated by the accompanying drawing in which the distance and obliquity of the radiations are shown, a curved line and a plane surface (see Fig. 18). This defect, however, is not sufficient to seriously interfere with the study of the skiagraph when the anti-cathode is placed over the center of the object exposed to the rays. This preliminary consideration will suggest the occasion of distortion and possibly assist in the appreciation of the following rules for locating the tube with reference to the objects to be skiagraphed.

(1) **Place the tube in position.** In case the size of the object and the relations of a foreign body are to be **considered,** regulate the distance so that the size of the object will be normal. The nearer an object is placed to the tube, the larger it will appear upon the screen or sensitized plate.

Experience has established the proper distance as eighteen to twenty-four inches from the anti-cathode.

(2) Place the tube at an angle at which the plane of the anti-cathode will be parallel to the plane of the table, or the sensitized plate otherwise placed, thus projecting the rays emitted from the center of the anti-cathode, where the cathodic rays are focused, and from which the most direct and the greatest volume of radiation is projected perpendicular to the plane of the anti-cathode.

(3) **Observe that the anti-cathode is over the center of the object** to be skiagraphed, in order that the perpendicular rays will be projected upon the object and those of relative obliquity upon either side, thereby avoiding distortion.

This rule is of special significance in localizing foreign bodies, and special care should be taken by a prior fluoroscopic examination for the purpose of determining the relative position of the foreign body or fracture before the skiagraph is made. When, however, skiagraphing two bodies for making relative observations, the anti-cathode parallel to the plane of the sensitized plate should be located over the center of the plate or at a point which will project the rays at the same angle upon the opposite parts. (See Plate No. VI.)

V. The exposure may next be made. The object, tube, and sensitized plate having been put in the proper relative

position for taking a skiagraph, the tube should, under most circumstances, be energized to the maximum capacity of the apparatus, and the length of exposures made relatively short.

VI. The length of the exposure will be relative to the quality of the tube, the density of the object, and the character of the apparatus employed, and in these conditions much latitude and diversity will exist.

Experience will be necessary on the part of the operator in the employment of his tubes and apparatus. Good judgment as to the relative penetration of tissues is necessary in order to definitely determine the length of time necessary to obtain the best results. The following tables will serve, however, as a guide in arriving at a definite technique.

Taking the hand as the minimum exposure, the two columns given will show approximately the range of time with different apparatus.

Hand	1 sec.	to 2	min.
Elbow	2 "	" 4	"
Shoulder	20 "	" 10	"
Chest	10 "	" 8	"
Skull	15 "	" 15	"
Foot	2 "	" 3	"
Leg	4 "	" 5	"
Knee	1 min.	" 10	"
Hip Joint	7½ "	" 20	"
Pelvis	1½ "	" 20	"
Stone in the Kidney	2 "	" 20	"

These figures are based upon results obtained from employing a static machine, having eight revolving plates for the longer periods of exposure, and a coil of twelve- to fifteen-inch spark resistance, capable of employing a current of ten to fifteen amperes, through the primary for the shorter. Between these limits, there is every degree of difference in the time required to obtain the desired results, and experience with the apparatus and tubes employed will perfect the operator in getting about the right exposure.

When it is decided to get outline of bone, it will be best to make the exposures relatively long. It is only in taking a

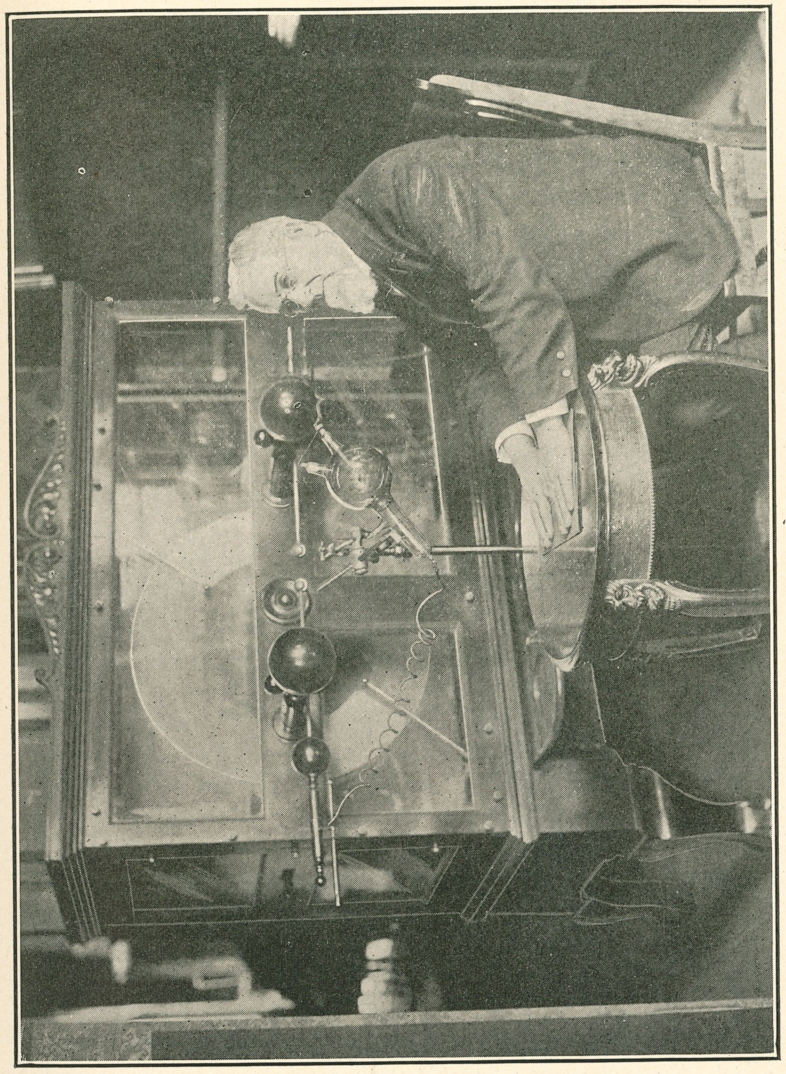


PLATE VI.—Method of Taking a Skiagraph. The Tube Placed in Such a Manner that the Plane of the Anti-Cathode is Parallel with the Plane of the Table; the Sensitized Plate Inclosed in Envelopes Opaque to Light.

skiagraph of the soft structures which are easily traversed by the rays that an overexposure, except extreme, will prove a failure.

Much is said, at the present time, on the subject of instantaneous skiagraphy. To effect this, it is necessary to place the tube closer to the object and employ powerful coils, and for practical purposes, except in case of stone and examination of the chest in which respiration interferes with the skiagraph, there is little advantage to be derived from so-called instantaneous skiagraphy. For all practical purposes, the skiagraph taken with the static machine, which will give a clear outline upon the fluoroscope, is satisfactory.

The time required with static machines having twelve to sixteen revolving plates is about the same as with most coils in general use, and the results are all that can be desired, except, perhaps, in the special cases referred to above.

The development of a skiagraph should, as a rule, be done by the physician who made it or under his personal observation. An exception may, perhaps, be made in cases where it is sought to define the bony structures, because they require less attention to detail.

The length of exposure and other conditions under which the skiagraph is made, as well as the quality of the tube employed, will determine in many respects the length of time which will be required to obtain definition. This, however, will not be accomplished by any fixed rule, but will require experience and careful observation on the part of the operator.

A plate which has been exposed to the radiance of a high-vacuum tube when taking an object of relatively slight density will appear very rapidly, and the process may be carried so far as to overdevelop the negative unless a retarder for slowing the process or a weaker solution of the developer is employed.

When a skiagraph has been taken under proper conditions for a calculus in the kidney or elsewhere, much care will be required, and a long period of development, with careful observation of land-marks during the process of development—requiring knowledge, experience, and care which will not be

given by other than an interested party, and can rarely be trusted to a photographer unless he has been specially trained by the physician who is familiar with the degree to which the process of development should be carried. It will rarely be the same in two cases, depending, as it does, upon so many conditions, as the quality of tube, character of apparatus, time of exposure, and varying physical characteristics of the different subjects skiagraphed.

A dark room for the purpose of careful development of a skiagraph, as in other photography, is a necessity. A large closet provided with facilities for washing the plate may answer the purpose, but will require care in excluding all light around the doorway. It is better that a room to be used for this purpose should be especially constructed and provided with two doors and a passage-way for entering the dark room, the outer door to be closed before the inner one is opened. This will permit ingress and egress during the process of development without admitting light into the room. Such a room should be ventilated by some means which will not permit the reflection or direct admission of light into the room.

The light to be employed during development should be a ruby light covered with orange-colored paper or glass, as the two colors exclude the rays most apt to affect the sensitized plate. A ruby lamp provided with glass windows will serve for this purpose, but is apt to smoke and cause disagreeable fumes in the dark room. If a lamp is to be used, it is better that it be situated on the outside of the dark room in front of a colored glass window provided in the partition which will admit the light at a convenient angle to the developing tray, or still better is an electric incandescent light in the dark room because there are no disagreeable fumes or odors emitted, and it is always convenient. A ruby bulb should be employed, over which may be placed a box made of the yellow paper which is provided for the outer envelope used over the X-ray plate. In lieu of the colored bulb two thicknesses of the yellow envelope tied over an incandescent bulb will serve a practical purpose. It will always be best not to employ even these lights too intense in the dark room.

The trays used in development for a complete equipment should include the sizes of the different plates to be used. While a large-sized developing tray may be used for small plates, placing more than one in the tray at the same time, to advantage; it will necessitate the employment of a larger quantity of developer each time, and as it is not always best to use a developer for more than one plate, it necessitates an unnecessary waste of material when but one plate is developed. The material of which trays are made is hard rubber, especially prepared composition, glass, or a porcelain-lined tin vessel, Fig. 19. The latter, which may be procured at department stores, will answer the purpose, except for plates eleven by fourteen inches, or larger. Two trays will be required un-

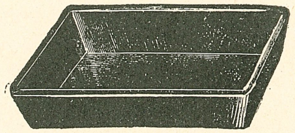


Fig 19.—Developing Tray.

less a fixing bath of wood or other material is provided in the dark room, the second one to be used for the fixing bath.

The developing solution may be made of various combinations and relative proportions of chemical substances which will wash away the unexposed portions of the silver compound upon the sensitized plate. The manufacturers of plates used for skiagraphic purposes advise various combinations in powders or tablets which are adapted for the purpose. These will generally prove satisfactory when used in the proportions as directed upon the package. They cost more, however, in these packages, and when it is known what the combinations are—usually some commercial substance as metol and hydroconone—it is cheaper to buy the materials in bulk and divide them in the proper proportions.

Operators who do much skiagraphy prefer to make their solutions and keep them in stoppered bottles, measuring out sufficient solution for the treatment of each skiagraph. These solutions may be made at a comparatively small outlay and are always convenient.

To develop a sensitized plate, enter the dark room, and having selected the tray and prepared the solution, remove the sensitized plate from the envelope, taking care not to allow too bright a light from the lamp or incandescent bulb to strike upon the film when removed. Take care that the film side of the plate is uppermost, and tipping the tray at an angle of forty-five degrees place the plate on the bottom. With a sudden movement, holding the tray so that the fluid will flow evenly over the plate in the bottom, lower the tray to the level of the table. If the film has not been completely covered by this movement, with a piece of absorbent cotton see that the whole surface of the plate is moistened, otherwise it will have a spotted appearance when developed. Whenever bubbles form on the surface of the plate and persistently remain in one spot, a tuft of soft cotton should be applied or blisters will appear on the plate when developed. Having thoroughly moistened the surface of the plate, continue a rocking motion from side to side, for the purpose of getting uniform action upon the bromide of silver which has been affected by the rays or affected in varying degrees by the exposure. The first appearance of the object will be as a white surface, the form of the limb or substance which has been exposed. As the rocking process is continued this surface gradually becomes darker, and if persisted in long enough will entirely disappear.

The outlined surface of the image will appear in most cases within the first minutes of development, and if the solutions are too strong or the exposure has been for a short period it will rapidly disappear. Under these conditions, the solution should be diluted by the addition of water, or, as some prefer, the employment of a retarder, or the plate should be promptly removed.

The retarder usually employed is a ten per cent. solution of bromide of potash. The quantity added will depend upon the volume of the fluid in the tray and the rapidity with which the image is changing and is added with a dropper.

The extent to which development will be carried and the time necessary to bring out the detail will depend upon the object sought. When developing a skiagraph which has been taken to show the bony structures, with a high-vacuum tube, definition and not detail will be desired. In these cases, the plate should be submitted to a rapid process and carried to the point that the bony structures begin to disappear as the operator looks upon the plate lying in the tray, i. e., until the whole surface of the plate looks dark, only the outlines of the bone being discernible.

When developing a plate for the purpose of bringing out the detail, as in cases where it is sought to show the presence of objects which the rays traverse to a greater extent than bone, a weaker developer should be employed and if the image disappears rapidly the retarder should be added and the process prolonged, or the object will have disappeared from the plate. In these cases, it will be difficult to determine when the development has been carried to the proper degree and which can only be judged by experience.

The operator should learn to fix upon some bony prominence and determine at what degree of development the structures sought, as calculi, are best indicated upon the sensitized plate, by the relative appearance, and so decide to what degree the process of development should be carried. This can be learned only by experience, and the success in making skiagraphs of this character will depend largely upon the good judgment, patience, and attention to technique of the operator. Washing the surface of the plate before placing it in the fixer will be the next step in the process. This may be done by allowing a stream from a faucet running at moderate pressure over the surface of the plate, or by immersing it in a water bath. Then place the plate, film uppermost, in the fixing solution.

To fix the plate in the solution of hyposulphite of soda will require but a short time, depending upon the strength of the solution. The salts which have not been affected by the light will then be dissolved from the plate, leaving only that portion of the coating which has been hardened by the action of the developer. The plate may lie in this solution for an indefinite time without injury. When the white appearance on the glass side of the skiagraph, however, has entirely disappeared, it may

be removed from the fixing solution and washed preparatory to drying the film. When there is an abundance of time and the plate will not be required for several hours, it is well to allow it to remain in the solution of clean water for twelve hours, or it may be accomplished in less time by allowing a

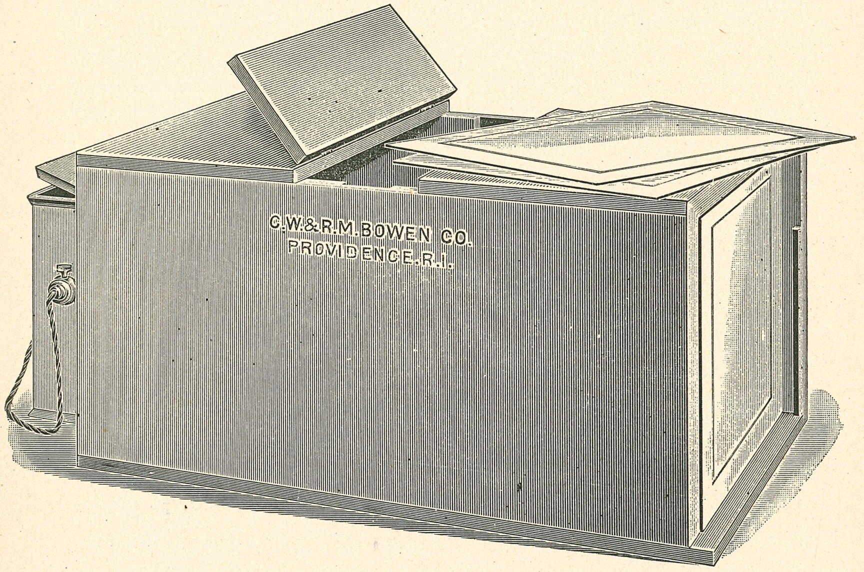


Fig. 20.

stream of water to flow gently over the film surface until it appears to be clean. The plate will not be sensitive to light immediately after it has been placed in the fixing solution, and may be removed or examined at any time after having been placed for a few minutes in the hypo. bath.

To quickly dry a developed plate pour alcohol over the film side, and then set it in position where an electric fan will blow against the surface. A plate may be thoroughly dried in this manner in a short time, preparatory to taking it from the premises.

A skiagraph is best studied in a subdued light, holding it at an angle in which it appears to the best advantage. A

ground glass held between the skiagraph and the light, so arranged that the light does not enter the apartment from any other source, will show it well. Another method is to examine the plate in a dark room, employing a box especially constructed, provided with a ground-glass side and an electric lamp in the interior which will enable the observer to detect all of the lights and shadows upon the sensitized plate. (See Fig. 20.)

Printing from the sensitized plate upon paper for the purpose of mounting is a simple process, requiring but little practice to accomplish it in a satisfactory manner. It should be borne in mind that when printed the skiagraph is a positive, not a negative, that the shadow picture upon the sensitized plate is in exactly the same relation as the parts were presented when the exposure was made, not as when a focusing lens is employed, when the image is reversed. A print of a skiagraph, as in photography, reverses the relation of the parts, the right hand appearing on the skiagraph as the left, and the liver as though it were on the left side.

Care then should be taken not to use the term negative when referring to the developed plate, but to refer to it as the skiagraphic plate. For printing various makes of sensitized paper may be employed, as the bromide, solio, or blue print. If it is desired to show particularly the detail of the picture, it will always be best to use a glossy paper instead of the mat or soft toned paper. When printing a skiagraph of the bony parts it will make little difference which sort of paper is used.

A self-toning paper which is practical and will not fade is to be preferred by the physician, who will find it inconvenient to be obliged to have at hand toning solutions as well as delay for washing after toning the picture.

Printing frames may be procured in the various sizes. They consist of a wooden frame having a glass front, and provided with a movable back and a spring for holding it in position. (See Fig. 21.)

The skiagraphic plate is placed with the film outward and the printing paper is placed over it in the back and then tightly closed to hold the paper in apposition during the printing

process. The exposure is then made either in direct sunlight, subdued light, or the light of an electric lamp, according to the character and sensitiveness of the paper employed.

Developing.—After the exposure has been made, some paper, as bromide, requires developing. Place it in a developing solution and develop the same as the sensitized plate.

Fixing will also be necessary and various formulas will be employed according to the requirements of each special paper, directions for which will be furnished by the manufacturer. Some experience will be required in order to carry out this process in the most rapid and successful manner, but by following the directions furnished with the particular paper which is adapted for use, it will not generally be difficult.

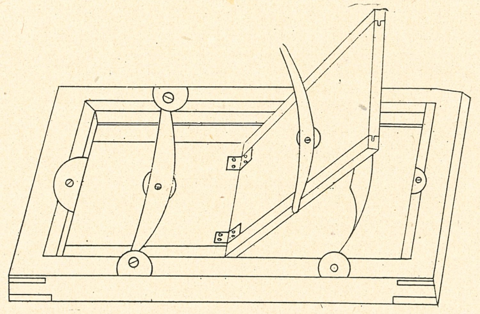


Fig. 21.—Printing Frame.

It is best always to employ the same plates, papers, and developers with which the operator will soon become familiar.

Stereoscopic radiography constitutes a method for showing a superposition of images from two skiagraphs of various planes and the distances which separate them. It is accomplished by taking two skiagraphs at different angles of exposure, substantially as follows: The object is placed in position upon the table before making the first skiagraph. A tube-holder, provided with a means for marking by a gauge the exact relative position of the tube to the object, is placed in position. The exact center of the object is discovered by measurement and the employment of a plumb line. The tube is so placed that the center of the anti-cathode is in position

with its plane absolutely parallel with the plane of the object placed upon the sensitized plate. The position of the anti-cathode over the object is then made one and one-half inches from the line suspended over the median line of the subject (representing, approximately, one-half of the distance between the eye of an observer). The exposure is then made and the plate removed. Great care must now be taken that the second plate is placed in identically the same relation to the object as the preceding plate, which may be accomplished by securing the patient in a position from which he cannot be moved and then placing the second plate by marking, or a purposely prepared gauge in exactly the position of the preceding sensitized plate. The tube-holder is now moved so that the center of the anti-cathode is one and one-half inches to the opposite side of the median line of the object, and the second exposure is then made.

These plates should be treated in every way in the same manner, the exposures being for the same period of time and the development carried to the same extent. For observing the pictures, a special apparatus has been designed. The one shown in the cut was designed by Dr. L. A. Weigel of Rochester, N. Y., and described by him in the New York Medical Journal of November 16, 1901. It is an instrument of more than ordinary merit and value. (See Fig. 22.)

Its use is described by Dr. Weigel as follows:

"The correct interpretation of X-ray negatives frequently presents considerable difficulty, because all parts of an object lying in different planes are projected into one, and there is practically no way of showing the superposition of the various planes and the distance which separates them. This defect of the ordinary skiagraph is readily overcome by making two stereoscopic negatives, which, when placed in the stereoscope, virtually reconstitute the object in space. Every detail of the negative is seen in its proper place, the surfaces appear in their natural form, and the various planes are correctly separated from each other.

"The stereoscope shown is adapted for studying the original negative, although it may also be used for examining full-

sized prints. It is constructed on the principle of the reflecting stereoscope invented by Professor Wheatstone in 1838. In this apparatus two plane pictures, representing slightly different views of an object, are superimposed and appear to the eye as giving the same relief as the object itself.

"As seen in the illustration (Fig. 22), it consists of a bed-piece upon which, at its center, two mirrors, inclined to each other at an angle of 90 degrees, are mounted on a slide having a forward and backward movement, to facilitate adjustment. At the angle formed by the mirrors a screen, with openings for the eyes, is placed.

"Two grooved frames for holding the negatives face the mirrors and are adjustable by a single sliding motion in two directions—one at right angles to the base, and the other parallel to it. In the base of the frames there is also a mechanism controlled by a milled-head screw, for vertical adjustment. By means of these various movements the image of the two negatives reflected in the mirrors may be quickly adjusted until they are accurately superimposed, and stereoscopic relief is obtained.

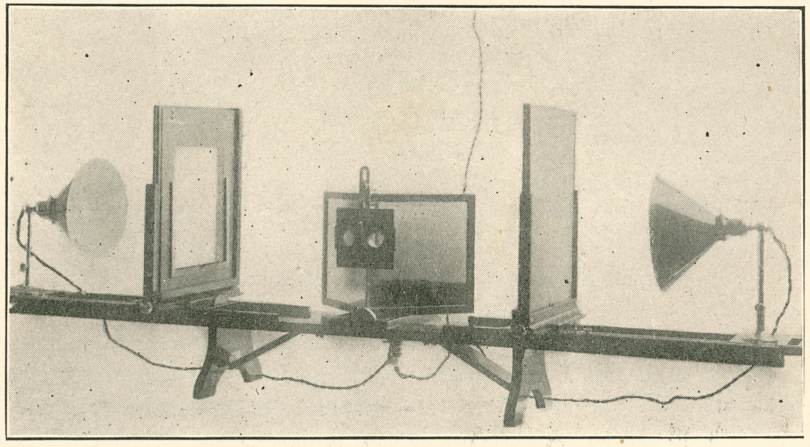


Fig. 22.—X-Ray Stereoscope.

"Transillumination of the negatives is necessary, and this is best secured by artificial light. The most convenient and satisfactory source of illumination is from an electric light. In my apparatus a sixteen-candle-power lamp is placed behind each negative. Flexible conducting cords from these lamps are wired in parallel to a single key-socket, attached to the under side of the bed. An electric-light cord of convenient length, and having an extension-plug at each end, is used to connect the apparatus, and the other is attached to the source of illumination selected. For concentrating the light on the negative an ordinary metal shade, or reflector, surrounds the electric-light bulb, which should be preferably of ground glass. An even diffusion of the light is still further secured by having one side of the negative frames covered with a sheet of ground celluloid, which is lighter and less fragile than ground glass. The lamp brackets are adjustable vertically, and, as they are attached to an independent base, the distance between the light and the negative may easily be regulated, according to the varying density of the plates. Where an electric-light plant is not available, Welsbach gas lamps, or acetylene bicycle lamps, may be substituted for the illumination.

"The negative-holders are square and large enough to take in plates of all sizes up to and including eleven by fourteen inches, and may be placed in the frames either vertically or horizontally. For the smaller-sized plates it is advisable to use masks of black press board, or other material, to cut off all extraneous light. The left-hand frame in the illustration shows a mask for an eight-by-ten plate in position."

When this method is employed, the structures are shown in perspective. The superposition of the various planes and distances between the structures are seen as in their natural position. A fractured bone will appear, showing perspectively the relative distance and position of the broken fragments. Looking into the chest, the appearance is as looking into a skeleton. Another singular feature of this method of examination is that, if the plates are reversed, it will appear as if looking from the opposite side. Foreshortening, in case exposures are made with the joints in a flexed position, is distinctly discernible.

The practicability of the method, however, except for demonstrating the possibilities has not been proved, and it is doubtful if it will ever become a recognized procedure on account of failure to show any special advantage that is to be derived from its employment.

CHAPTER V.

PRACTICAL SKIAGRAPHY.

A PROPER conception of the power and character of X-radiance is essential to its intelligent use in diagnosis. It must be understood that a skiagraph is a relative expression of the penetration of the parts of the object by the X-ray. It shows upon a plane surface the relative shadows of tissues of different densities which had intervened between the tube and the sensitized plate, varying with the character of the rays, time of exposure, method of development, etc. In other words, a spherical body is represented as a flat object, except possibly of a varying thickness and density, as that of a bone, which will show darker shadows at points of greater compactness or thickness. Foreign bodies, muscle, fat, and skin will appear in varying shadows in proportion to their penetrability. It must be borne in mind, therefore, that to radiograph small organs or tumors which are easily traversed, when bone or muscle intervene, is practically impossible.

The relative penetrability of structural and pathological conditions is from greater to lesser in the order named as follows: Bone, muscle, blood, cartilage, pus, fat, and integument.

Structures the seat of active suggestion, as the lungs in pulmonary tuberculosis and pneumonia, aneurism of the large vessels, or pus cavities, present well-marked shadows.

For purpose of diagnosis the X-ray is valuable in many conditions,—in fractures and dislocations, foreign bodies lodged in the tissues which are of substances impenetrable to the ray, calculi in the kidneys, bladder, ureter, or gall-bladder,—also in examinations for differential diagnosis, or for the purpose of determining the prognosis in affections of the bones, joints, or the diagnosis of aneurisms, and for examination of the viscera.

In diagnosing fractures and dislocations a fluoroscopic ex-

amination should first be made for the purpose of determining at what position the skiagraph will best show the conditions present, and then two skiagraphs should be made, the exposures of which should be at right angles to each other, and in such a manner as to give the best expression of the deformity, as determined by the fluoroscopic examination.

The localization of foreign bodies which have been swallowed or lodged in the tissues often requires a degree of dexterity, skill, and a knowledge of the technique only obtained by special training and experience. It is this particular de-

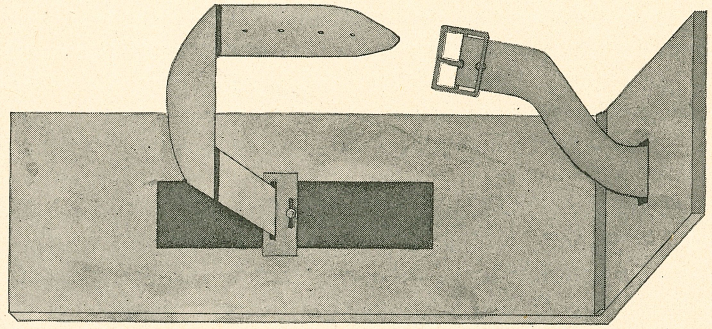


Fig. 23.—Gauge.

partment of the work which has so often brought radiography into disrepute with the surgeons.

The quality of tube best suited for this work will, in most instances, be one of fairly high vacuum, because objects to be located are generally of metal, and detail is then of little importance. If, however, it is sought to locate an object easily traversed by the rays, it will then be necessary to employ a tube of low vacuum. The time of the exposures will be made relative to the part in which the foreign body is to be located.

In the case of a needle or a bullet in the hand or thin portion of the foot, it may be necessary to take but one skiagraph to locate the object.

In the thick portions of the body, as the trunk or limbs, it

will be necessary to make two exposures, which should be made at right angles to each other in order that the object may be located in both depth and lateral positions. In order to make certain that these exposures are made at right angles, it is desirable to adopt some method easily accomplished and accurate. Besides taking the skiagraphs at right angles, it is also necessary to have some mark upon the limb or body to indicate the exact relation which the parts bore to the sensitized plate when the exposure was made.

The writer has adopted the following *modus operandi*, which he finds both simple and practical. A gauge (see Fig. 23)

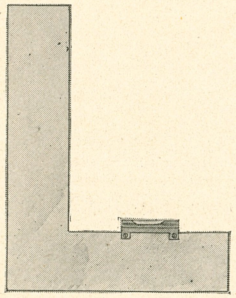


Fig. 24.—Square and Spirit-Level

is made of a strip of board one-half inch in thickness, three inches wide, twenty inches long, having another piece of the same thickness, three inches square, nailed at right angles. An opening in them may be made in each, through which a strap will pass in such manner that the gauge be secured to the limb or body of the patient as shown in Fig. 26. A square, such as artists use, to one side of which is screwed an adjustable spirit-level, shown in Fig. 24, is used in placing the gauge in two planes, which shall be at right angles to each other. Instead of the spirit-level a plumb line, suspended as shown in Fig. 26, will serve the same purpose. In addition to these devices, it will be necessary to have some provision by which the relative position of the limb to the plate can be determined at the time of an operation. This may be done in the following manner: two screens made of two sizes of wire, as shown

in Fig. 25, should be strapped to the limb at the same angle and relative position as the gauge when the skiagraph is taken. These should be securely strapped to the surface next to the patient's skin, to be left in position until the time of the operation, when upon removal the imprint upon the skin, which will remain for some time after removal, will indicate the square marked by the screen corresponding to the same square in the skiagraph in which the foreign body will be located. The operator will by this means be able to determine the relative transverse and vertical positions of the foreign body. The *modus operandi* is illustrated in Figs. 26 and 27.

The presence or absence of calculi in the gall-bladder, kidney, or ureter may in many cases be determined by the skia-

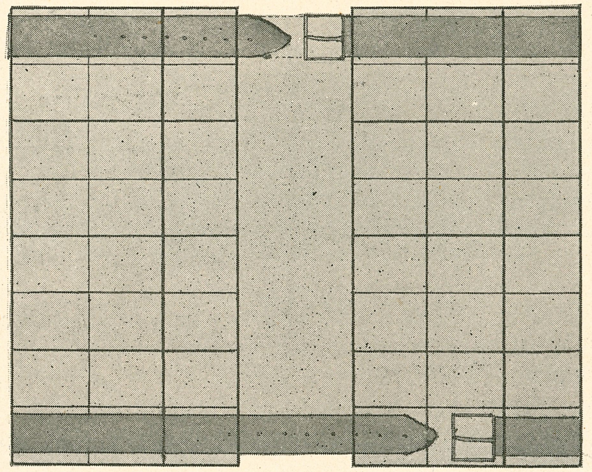


Fig. 25.—Localizing Screen.

graph. It will be impossible to determine their presence with a fluoroscope because the image upon the screen does not give the same degree of detail as the impression made upon the sensitized plate. There is no other procedure in radiography which calls for an equal amount of skill and familiarity with the apparatus and details of the manipulation. It will then be impossible to locate a stone in very muscular and obese objects.

Small calculi and those of the salts of the phosphates will be difficult to determine.

The apparatus best suited to this class of skiagraphy is a powerful coil capable of passing a ten- to fifteen-ampere current through the primary. These coils again require special tubes, having heavy anti-cathodes of platinum or provided with a water-cooling device to prevent the melting and destruction of the anti-cathode. The tube at the time of the exposure

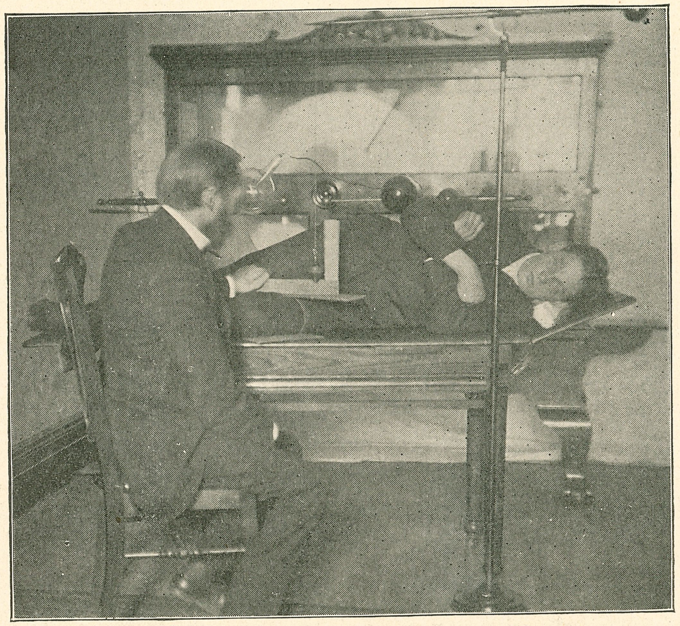


Fig. 26.—Method of Locating Foreign Bodies. First Exposure.

should be of low vacuum, otherwise the impression of the objects sought would not appear on the sensitized plate, the rays having traversed its substance.

Another matter of importance is the necessity of the absolutely fixed position of the object during exposure. The patient will of necessity be compelled to abstain from breathing during the intervals of radiation. This is best managed by strapping him to the table after the sensitized plate has been

placed in position and then instructing him to breathe at intervals, as signaled, always taking the same depth of inspiration, and exhaling it softly. At the instant of the patient's taking an inspiration, the current is to be cut off. By this plan, the movements of the diaphragm will not interfere with the relative position of the calculus. With the apparatus above described, the exposures need not exceed three to five minutes.

The development of the negative in these cases requires a degree of skill and familiarity with the work which will deter-

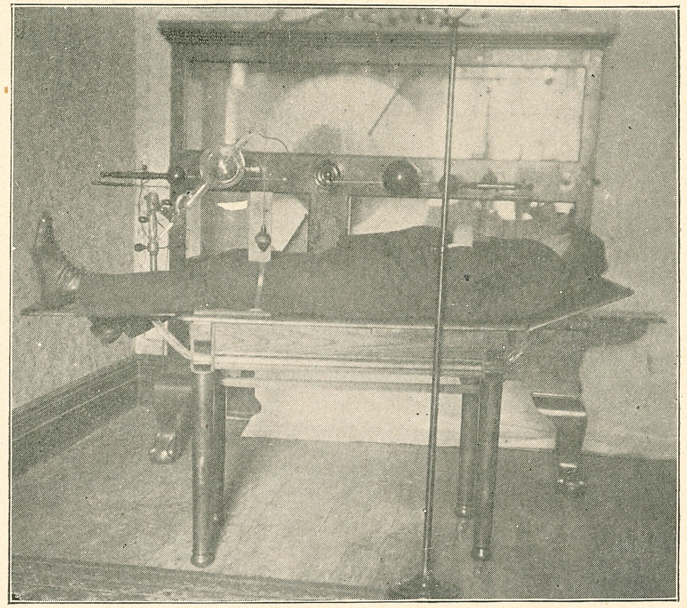


Fig. 27.—Locating Foreign Bodies. Second Exposure.

mine the success or failure of the diagnosis. It should be the habit of the radiographer to have some landmark, as a rib, the body of a vertebra, or the crest of the ilium, to guide him in the process of development in carrying it far enough and not too far to bring out the proper detail.

Experience will be necessary to become proficient in a process so technical. It will not be possible in a dark room

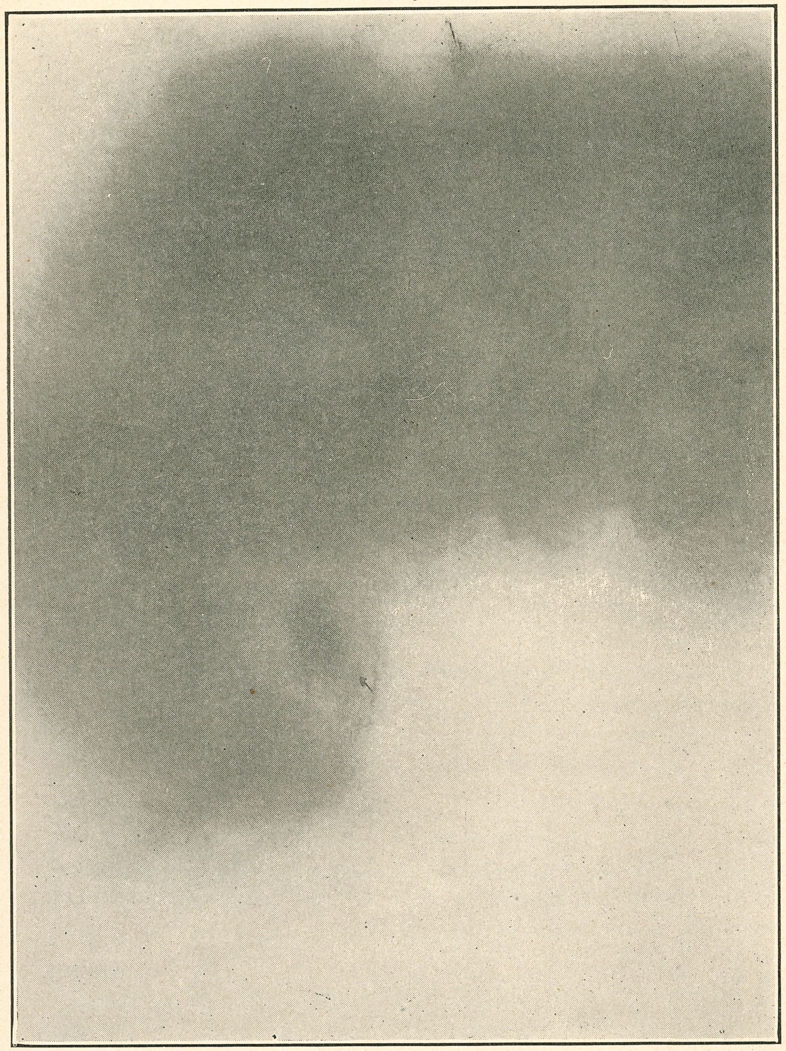


PLATE VII.—Calculi in the Gall Bladder, from a Skiagraph by Dr. Boggs.

to read the skiagraph. The negative should never be rapidly developed when it is sought to obtain detail in the skiagraph, as in cases of stone. It will, therefore, be necessary either to use a slow developer or have a retarder, as a solution of bromide, ready to add to the solution. If the image comes up too rapidly, either dilute the solution or add a retarder, as suggested.

Another important consideration is the character of the contents of the alimentary canal at the time the skiagraph is made. The patient should be prepared as for an abdominal operation, with the intestines as nearly evacuated as possible.

When taking a skiagraph for stone with a static machine or a small coil, it will be necessary to make these exposures for from ten to thirty minutes, and often without favorable results. In these cases, a second skiagraph should not be taken without an interval of at least five days intervening between the exposures, in order to avoid the possibility of dermatitis.

The skiagraph pending a surgical operation for stone is a matter of somuch importance, and the possibility of imperfections in the plate so possible, that at least two skiagraphs should be taken in all cases to confirm the presence of a suspected calculus.

Biliary calculi were for a considerable time skiagraphed with so much difficulty that the possibility was questioned. Drs. Beck and Boggs and others have since succeeded in making it no longer a question of doubt. Undoubtedly for the greatest measure of success in these cases, technical skill is required both for controlling the respirations of the patient and the management of the powerful coils above described. The accompanying skiagraph shown in Plate VII., taken by Dr. Boggs, is an excellent example of the success of the procedure.

Stone in the kidney has been demonstrated so many times and by so many excellent authorities that it has become a recognized means of diagnosis, and is looked upon as essential to the operation for removal. The reading of a skiagraph in these cases requires some familiarity and experience in order to detect its presence in cases in which the definition is not

distinct. It will always be better to study the developed plate in a subdued light before a light-colored background, preferably ground glass, than the print for the purpose of discovering the presence of the calculi, bearing in mind that a light spot on the film indicates the presence of the foreign body (the reverse from the printed copy). In these cases it should also be remembered, as in all others, that the sensitized plate gives the positive impression and that the print is a negative, otherwise a mistake would result and a stone be thought to be in the wrong kidney. Likewise in the skiagraph shown of stone in the gall-bladder, the object appears to be upon the left side of the body, because the print of the skiagraph is a negative.

Stone in the bladder will call for the same precaution in the matter of respiration, though not of as much importance as in the biliary cases. The abdominal breathing, however, causes sufficient movement, especially in males, to interfere with the success of the process.

Stone in the bladder, to be best shown upon the plate, demands posturing the body at forty-five degres to the table or chair in order that the rays may be projected perpendicularly through the pelvis to the sensitized plate. In other respects, the technique is practically the same as in the exposures for calculi already given.

The diagnosis of tumors—of sarcoma, tubercular joint conditions, and osteophytic growths—is one of much importance. The history of the case will assist in making the differential diagnosis and the presence of the tumor of the bone will confirm it, at the same time determining its extent. No particular technique is essential other than in the diagnosis of fractures. A medium-vacuum tube or a low tube energized to a degree to give a distinct outline will be found most satisfactory, except in cases of the hip joint, when a high tube will be required. In the differential diagnosis and for purpose of prognosis, in cases of joint lesion and tubercular, rheumatoid, and osteoarthritis the skiagraph will be found valuable. (See Rheumatoid Arthritis.) Plate VIII. shows a tubercular condition of the bones of the hand.

PLATE VIII.—Diagnosis of Bone Tumors. Tuberculosis of the Finger, by Dr. Geyser.

The diagnosis of aneurism is one of the recognized valuable procedures accomplished with the X-ray. The blood being less easily traversed by the ray than the other tissues, except bone and muscle, makes it possible to obtain a distinct shadow of an aneurismal tumor. So also inflammatory areas will show a darker shadow than under normal conditions.

Pus cavities likewise are more opaque than the normal conditions. Examination of the viscera by the X-ray, especially of the lungs, heart, and liver, and under certain conditions of the spleen and stomach, is a subject calling for careful consideration. The condition of the lungs in which the X-ray has proved a valuable measure is the diagnosis of incipient phthisis, for which the fluoroscopic screen is most satisfactory. In these cases, the apices, the usual seat of the incipient invasion, appear hazy, whereas the portion of the lung unaffected appears clear, as in the normal chest.

The method adopted by Dr. Stubbert of holding a metal rod transversely across the chest, dividing the image for the purpose of comparison, will facilitate the examination. By inspection of the upper portion of the images thus made it will be easy to determine the relative penetration of the rays upon the screen and a diagnosis will be rendered more certain.

Cavities may often be shown in the lungs with a calcified or fibrous ring surrounding them.

Pleurisy with effusion may be easily diagnosed with the patient in the sitting posture, the level of the fluid being distinctly shown upon the fluoroscopic screen.

Empyema may likewise be diagnosed and the experienced eye will detect the differential diagnosis from pleurisy by the fluid, the shadow being distinctly darker. The diagnosis of localized chronic pneumonia, large pus cavities, and atelectasis may be confirmed by the X-ray.

Displacement and hypertrophy of the heart may be demonstrated with the X-ray. On account of the fact, however, that the heart is constantly in motion, it will be impossible to get a distinct outline, except the exposure be made instantaneous, and even then it will be impossible, except by chance, to obtain a definite image. The general outline and position, how-

ever, may be satisfactorily denoted upon the skiagraph, except in very muscular subjects.

An enlarged liver, on account of its vascular structure, will be readily shown on the skiagraph. A dilated or displaced stomach may sometimes be diagnosed by giving the patient very large doses of subnitrate of bismuth. In this case, however, it will be necessary to evacuate the alimentary canal, and success can only be obtained in cases in which the muscular development is slight.

The general principles, including the technique of the above procedures, will suggest other additional uses for diagnostic purposes.

SECTION III.

RADIOTHERAPY

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CHAPTER I.

INTRODUCTION.

PROBABLY no subject in recent years has taken stronger hold upon the medical mind than the prospects of the X-ray in the treatment of diseases of many types which have heretofore resisted all measures. It seems that a new area is dawning, and that the future has greater possibilities in store for the alleviation of human suffering.

Those who, since the discovery of the Roentgen ray, had employed it therapeutically, until the past two years, were few, and the satisfactory results were confined to superficial neoplasms.

The field at present, however, offers so much, and the possibilities of effecting favorable results in the treatment of malignant diseases by its aid are so encouraging, that many physicians who have heretofore been entirely unfamiliar with the employment of electricity or of the Roentgen ray are now disposed to investigate the subject.

For the reason that mistakes are easily made timely caution should be given, and an honest effort put forth by members of the profession to become enlightened both as to the best methods of operation, and the dangers to be encountered, before attempting to employ the X-ray.

While it is not absolutely necessary that those employing the Roentgen ray should be familiar with the technicalities of electrical science, it is most desirable that the physician who intends to employ it should know the general features of the subject, as well as the possibilities and construction of the apparatus, and the action of the agent he employs. It is also a

matter of great importance, in order that the best results may be obtained, that the operator understand the use of other electrical modalities which are employed therapeutically with advantage in connection with the X-rays.

While the dangers arising from the use of the X-ray in the treatment of diseases are relatively small, it is certain that there are dangers when proper precautions are not taken. On the other hand, to obtain favorable results in many grave cases of deep-seated tumors requires that the rays be employed to the utmost degree of toleration, taxing both the skill and tact of the operator to determine the limitations and the dangers to be encountered.

The individual idiosyncrasies, while to a certain extent marked, are not fraught with sufficient danger, except in deep-seated cases, to preclude effective employment. There is, however, a slight predisposition on the part of a few patients who are affected by an early dermatitis. These, under ordinary precautions, need never exceed the second degree. There are, indeed, few superficial cases in which the want of toleration is sufficient to prevent an effective employment of the ray. It is, therefore, a matter of great importance, both in the interest of science and humanity that those who presume to employ the X-ray should become familiar with the methods. It is not assumed, at this time, that the *modus operandi* at present in vogue will not be improved upon, but it is to be hoped that the present methods will prove a safe guide to those who study the new science.

Conservatism on the part of those who are obtaining successful results is most desirable, lest others who do not employ the Roentgen ray may attribute to them an excess of enthusiasm. It is wise, therefore, when possible, that the diagnosis of malignant cases be confirmed by microscopic examination before treatment is instituted. If this plan be generally adopted the accumulated evidence in time to come may be a guarantee of the effectiveness of the X-ray in therapeutics.

The diseases to which attention has already ben called, as being influenced by the rays, belong generally to the types of heretofore intractable conditions. Probably its employment in

the treatment of the forms of sarcoma and carcinoma, associated with surgery, offers one of the greatest triumphs of the new method. Already other remedies had been found for the successful treatment of the forms of lupus, but the malignant diseases had generally defied the surgeon's knife unaided, until the discovery of the wonderful properties of the Roentgen ray affords assistance which will add to instead of take from the glories of surgery.

Failure to observe a cautious and correct technique has already thrown much discredit upon the institution of the new measure, and will until the dangers are understood and physicians become familiar with the numerous aspects of the subject.

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CHAPTER II.

PHYSIOLOGICAL EFFECTS OF THE ROENTGEN RAY.

LITTLE has been written upon this subject, and at best only approximate conclusions can be contributed at this time.

It has been generally conceded that the X-rays are a form of energetic vibration marked by an intensity which exceeds the rate of vibration at the violet end of the spectrum. We know them by the physical characteristics by which their presence is manifested—not seen. A study of the manifestations, or the physical characteristics, of the Roentgen ray affords the only basis for an understanding of its actions, except so far as it is possible to investigate clinically their effects upon the body under varying conditions.

That the vibrations are electrical discharges there is no reason to believe. The light emanating from the electric arc is the product of electrical discharges between the two poles of a circuit of relatively low voltage and large amperage in the earth's atmosphere, and the X-ray is the resultant of the two polarities of very great potential and small quantity produced in a tube of high vacuum. Both result from the mingling of the discharges of opposite polarities under favoring conditions, and as such are not electrical but consequent products.

Some have attributed the effects upon animal tissues to the high-potential discharges at the terminals of the tube. Nothing is more improbable to those familiar with high-potential discharges.

The study of the actions of the X-ray is the study of the effects of form of vibration—agitation of the ether of the highest recognized intensity. It is an invisible force, and, like other invisible forms of vibration, can only be comprehended by the results arising from its actions.

The physical characteristics are as follows:

I. They penetrate many substances which absorb the visible rays of the spectrum.

II. They are refracted * when passing from one medium to another of different density.

III. They are but slightly reflected, and are absorbed by substances which they do not penetrate, and cause others to fluoresce.

IV. What the peculiar effect of the rays may be upon the protoplasmic structures of the body as they pass through the tissues can only be determined from the conditions arising, which are as follows:

(1) As one stands before the radiating tube with the rays penetrating the body, there is little perceptible sensation. It may have been noticed, however, if the hand be held before the tube for several minutes that a sensation of gentle contraction of the skin is perceptible. The statement of this fact is not uncommonly made by patients under treatment by the X-ray.

(2) It is also observed that the surface of an ulcerating, cancerous growth appears as if glazed or as covered with a thin coating of collodion after an exposure of several minutes.

(3) The substance of a growth, when standing prominently above the surrounding surfaces, is also perceptibly contracted.

(4) Following a series of exposures it has been observed by all familiar with the subject that the skin becomes atrophied, and the hair follicles and sweat glands become inactive—hair falling out and secretion of sweat ceasing.

(5) Pain is in most cases relieved to a remarkable extent after a few exposures in various inflammatory and malignant conditions.

(6) Congestion is evidently diminished, and is indicated by the relief of conditions which could be explained under no other hypothesis, occurring, as it does, when inflammatory conditions are exposed to the influence of the rays.

(7) Long or repeated short exposures produce dermatitis and necrosis, deep or superficial, according to the length of exposure.

* Recent convincing reports affirm that the X-Rays are refracted, contrary to Roentgen's first statement.

The above propositions, jointly and severally, point strongly to one effect in particular, which accounts for all—*the contraction of cell protoplasm.* The sense of contraction of the normal skin, the glazing and contraction of an ulcerating surface, the atrophy of the skin, and the relief of pain and congestion are all indicative of tissue contraction. Indeed, it is the most plausible explanation of the impaired nutrition, for necrotic and sloughing tissue, normal or diseased, betokens a diminished blood supply—local anæmia; due to the consequence of the contraction of the muscular coats of the vascular system. Whether the action is the influence upon the end plates of the neurons or upon the individual cells it would be difficult to assert.

The writer in a former contribution presented a statement of the results of the action based upon clinical observation: "That the effects of the X-ray upon the normal tissue are (1) to induce normal activities, due to the vibratory effect of the rays, or of the ether in the presence of the rays. (2) That these effects with short exposures at proper distances with high vacuum tubes induce activity of normal tissue cells, which, in some cases, supplant abnormal tissue elements without evidences of disintegration. (3) That exposures destroy only the abnormal tissues unless they be too prolonged. (4) That abnormal tissue thus exposed breaks down and disappears through the natural channels of absorption or by sloughing." It has been shown in the writer's experience that tissues of low vitality are always the first to break down.

It is probable that the vitality of all tissue is lowered by cutting off the blood supply. *Naturally*, under such circumstances, tissues of low vitality are the *first* to break down. It is also well established that the tissues of debilitated patients do not resist the destructive action of the rays as do those of normal individuals, which confirms the theory.

It has also been demonstrated that malignant tumors in the aged or infirm are more likely to soften and break down than in normal individuals, which confirms the view that when for any reason the tissue resistance is lowered the tissues break down. The violent toxæmia occurring under such conditions

is not due to extension of the malignant process, but to the auto-infection arising from absorption of toxins present in the broken-down structures.

This effect upon circulation and nutrition when employed to the extent of destroying malignant growths is at best a dangerous one, and demands careful attention to the management of details and a knowledge of the consequences.

The cumulative action is a striking feature of the effects of the rays and demonstrates the more or less persistent condition of contraction which follows a series of exposures, and explains the diminished metabolism after long exposures or series of exposures.

It would seem, therefore, that the logical explanation of the action of the X-ray when nearby, prolonged, or frequent administrations are given is, that the exposed structures contract at the expense of nutrition and produce, when carried to a certain degree, necrosis of the parts. This theory accords with the therapeutic results obtained from nearby and prolonged exposures.

The stimulating or tonic effect of the Roentgen ray, induced by short exposures or with a high-vacuum tube at distances of sixteen to twenty inches from the anti-cathode, is probably due to the disposition of the vibratory influences of the rays to first overcome local stasis, restoring tone to the muscular coats of the arterioles, and at the same time inducing a more active local metabolism.

A knowledge of the action of all stimulants teaches that their employment must be judicious or the opposite effects will result. So with the X-ray, to obtain the tonic action, exposures must be infrequent (not oftener than twice weekly), with penetrating rays emanating from a tube usually at a distance of from twelve to twenty inches. The length of exposure under these circumstances may be for the usual period of ten minutes.

Pathological changes which follow the administrations of the X-ray confirm in most instances the actions as given.

Germ life has not been demonstrated to be susceptible to the direct actions of the rays, as has been shown by many ob-

servers. What does seem to be the case, however, is that the pabulum is rendered unsuitable for their existence, and they perish.

The structural changes taking place in the tissues are consistent with the theory of the diminished supply of nutrition. Fatty degeneration, atrophic changes, degeneration of the nuclei of the cells of the sarcoma, and necrosis may all occur from such a cause.

Future developments and observations will still farther elucidate this interesting question.

CHAPTER III.

THE GENERAL PRINCIPLES OF RADIO-THERAPY.

THE therapeutic uses of the X-ray, in order to have associated the minimum of danger consistent with the greatest amount of benefit to be derived, require a technical knowledge of the actions and the limitations to which it may be employed.

Many physicians who make use of the X-ray have thought it necessary to make contracts with their patients, exempting them from all responsibility in case of serious X-ray burns. To the writer this seems an indication of unfamiliarity with the subject, because, when properly used, the patients seldom suffer more than a first degree of dermatitis. In rare cases, however, a dermatitis of second degree may be produced, which will disappear under simple treatment.

If the patient at the commencement of treatment is given to understand that a dermatitis is certain to be induced, and that it may be of the second degree, and of the danger of auto-infection, no responsibility will rest with the physician, and he who invariably makes the statement to his patients will require no better evidence than their testimony to substantiate his position.

In order, however, to avoid litigation it should be the rule of physicians to inform patients that dermatitis of the second degree may arise, explaining to them the character of the condition. Very few patients will be deterred by such small risks from taking the treatment to relieve them of the severe conditions generally present. In the treatment of acne and other superficial conditions, or when the X-rays are used for their tonic effects at the proper distance, it will not be necessary to

make any explanation, because in such cases the exposures will never induce, under judicious management, any dermatitis whatever.

The physician, however, must understand the limitations and the extent to which he can carry the X-ray exposure, that he may not go beyond the point of producing a greater degree of destructive action than a second-degree dermatitis. Some in the past have made exposures daily, and for periods ranging from ten to fifteen minutes, making a series of exposures, which in most cases would have given disastrous results. At the present time, however, the experience of a large number of observers has established rules of administration which place the measure within the range of safety.

In every case the operator should have in mind two things: (1) The actions of the X-ray, and (2) the extent to which the exposures can be carried with safety.

The length of exposure may depend upon the character of the lesion, the quality of the tube, the character of the energizer. and the distance at which the tube is placed from the patient.

The distance at which the tube is placed may, on the other hand, regulate the other difficulties of condition, and the time be made a constant factor; in other words, a low-vacuum tube may be placed nearer to the parts to be rayed and the time remain the same, or a high-vacuum tube may be placed at a greater distance for the same period, or a tube of medium or low vacuum energized by a large ampere current or a static machine provided with a spark interrupter placed at a shorter distance than in case of a high-vacuum tube. Some have made the rule an inch a minute; in other words, a tube in which the anti-cathode is placed one inch from the surface to be exposed for one minute. This rule, however, would not be consistent with the different power or penetration or the varying capacity of different tubes variously excited. It will be readily seen by the student that many factors enter into the question of distance and length of exposure.

Experience both with reference to different subjects and different apparatus will be required to enable the operator to

make precise and definite rules of action whereby he will be enabled to judge of the relative penetration or volume of the radiance employed, to govern the regulation of distance and time.

The frequency of exposure calls for careful consideration and is employed in relation to distance and time. In the majority of cases, the best results will be obtained and the greatest degree of safety assured by making the exposures at intervals of two days.

The cumulative action of the X-ray is such that in certain cases it will be found that even with every other day exposures a second-degree dermatitis will be produced. Had exposures in such cases been made daily, it is doubtful if it would not have resulted in a serious X-ray burn involving the deeper structures. To the present time, no cases have been recorded in which unfavorable results have occurred from the superficial action of the X-rays where the rule has been to employ the ray for ten minutes with the static machine and for five to seven minutes with the coil actively energized, making exposures on alternate days, with the patient at an average of ten inches for the anti-cathode, and raying has been discontinued at the appearance of a dermatitis.

The writer would therefore suggest from his own experience that a safe rule of action is to make exposures of ten minutes each when employing the static machine, and five to seven minutes when employing a coil actively energized, at a distance of ten to twelve inches from the anti-cathode, when using a tube having from two- to four-inch spark resistance, and from four to eight inches with tubes having from one-half to two-inch spark resistance. These administrations should be made, beginning with the first days of treatment, invariably on alternate days. It has been advised by some authorities that exposures may be made twice weekly, making the periods of exposure fifteen minutes each, with as good results. This, however, does not accord with the writer's experience. With a patient in whom a degree of hardihood is found to be present, it may be wise to make exposures on two or three consecutive days after the case has been rested for months.

In cases in which the fact of such hardihood is not established, it will never be wise to pursue a course of daily exposures.

The above rules apply, in a general way, to the therapeutic employment of the X-ray, and in whatever cases it is employed for the removal of malignant growths or neoplasms, they will be found to be safe.

The choice of special tubes and the technique of exposure in special cases will be considered when taking up the treatment of the various conditions in the subsequent chapters.

Screening of the parts not requiring X-ray treatment is a subject upon which operators are somewhat divided, some preferring to ray widely. The following rules, however, may be generally accepted:

(1) When raying the trunk of the body, there should be no indications to expose the face or extremities, which will be wisely screened.

(2) When raying the face or extremities, on the other hand, the trunk should, as a rule, be screened.

(3) In treating epithelial growths of the face, the surrounding parts, including hair and mustache, when the contiguous parts are not involved, should be properly screened. In all cases, the screen surrounding an epithelial growth should be so shaped that a margin of one-quarter to one-half inch in width is uncovered surrounding the ulcerated surface, in order that no indurated tissues may escape exposure.

(4) When treating any extensive affection of the face, as acne, particular pains should be taken to completely cover the hair to the margin as well as the eyes and eyebrows, thereby avoiding an accidental alopecia. (See Plate XIII.)

(5) When raying the cases of primary or recurrent cancer of the female breast, it is unwise to screen the part extensively. The writer believes that in these cases only the arm and the face should be screened, and that two exposures should be made at each sitting, the first directly over the lesion and the other from the side, in the latter the perpendicular rays from the anti-cathode being directed to the axillary space.

The material of screens employed by the writer in his clinic and practice is a composition of rubber with metallic sub-

stances, which effectually absorb enough of the rays for safety. About the face, tinfoil or soft metal composition thirty-two gauge in thickness proves effective.

The writer employs three shields of the rubber composition

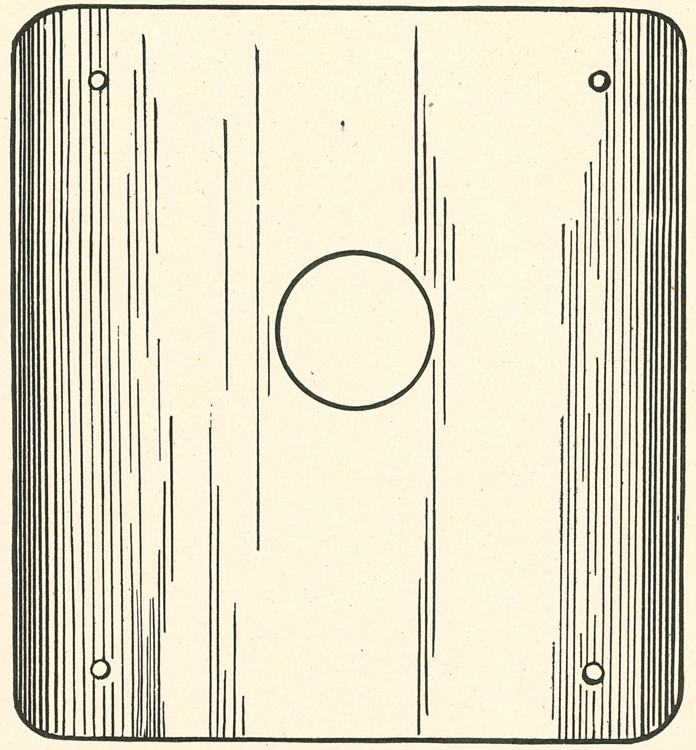


Fig. 1.—Large X-Ray Shield.

which are found convenient for use in a variety of conditions. (See Figs. 1, 2, and 3.)

Tanning is a term applied, as the word implies, to producing a dark or bronzed appearance of the skin which is supposed to be associated with a hardened condition not so liable to dermatitis. The writer's experience in bringing about such a condition has not proved eminently successful, for when the raying is pushed far enough to be effective in the treatment of

malignant disease, a dermatitis will sooner or later occur, after which, instead of the part becoming less susceptible to a recurrent dermatitis, it is apt to recur after fewer exposures than the number which first produced the condition.

Idiosyncrasy to the action of the X-ray is not as common as has been generally supposed. The period of time in which a dermatitis will appear, however, varies considerably with different patients. But rarely, with the plan of raying described above, does it occur within three weeks and some-

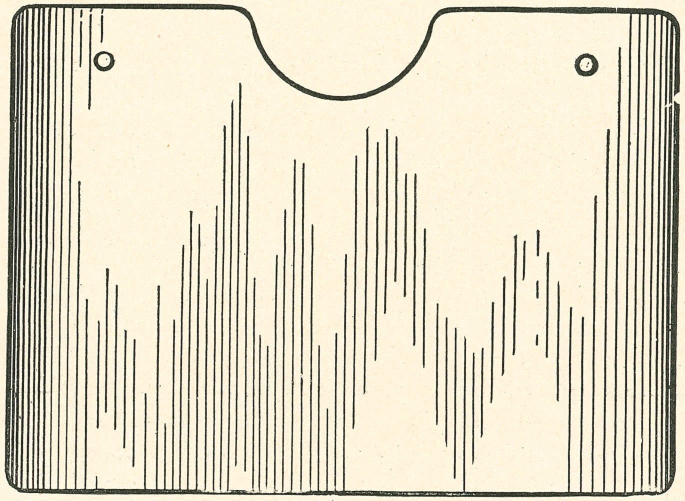


Fig. 2.—X-Ray Shield.

times it may be deferred to six weeks. In one case (a blond) treated by the writer, exposed upon alternate days, dermatitis did not appear until after the sixth week, when instead of the usual first blush of superficial dermatitis the patient suddenly acquired a painful second-degree dermatitis, indicating strongly the cumulative effect of X-ray exposures. It is also noteworthy that in patients in whom vitality is lowered for any reason, dermatitis appears earlier, and is apt to be most severe. It has been supposed by some that blonds were especially susceptible, responding earlier to the irritating effects of the X-ray. This has not been borne out in the writer's

experience, of which the case above referred to was an example. Various rules for the first exposures of patients have been made, some advising that the exposures at first be made at intervals of one week, after which the treatment should be taken up according to the regular plan of exposures. If an idiosyncrasy of so marked susceptibility, calling for such remarkable precaution, has been discovered by others, their experience differs materially from that of the writer.

Various accessories will be judiciously employed in connection with the X-ray in the treatment of superficial affections.

The brush-discharge administered with the wooden elec-

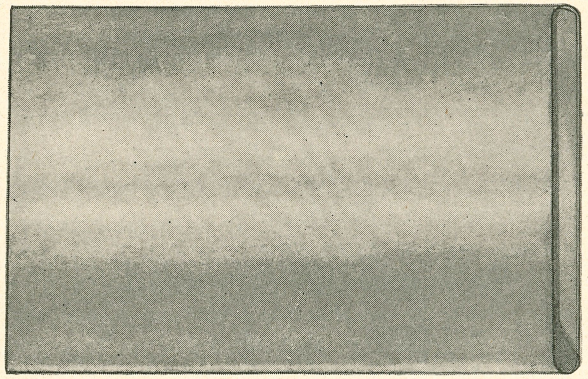


Fig. 3.—X-Ray Shield for Arm.

trode will prove invaluable in the treatment of lupus vulgaris, extensive epitheliomas, rodent ulcers, psoriasis, indolent ulcers, eczema, and sycosis.

The ultra-violet rays have already been demonstrated to be useful in the treatment of cases of lupus, especially of marginal growths, as the lobe of the ear, which would be sacrificed if the X-ray were energetically employed, and in few cases could be cured without the employment of additional measures. It also seems, from the experience of recent writers, that light is of value, used on alternate days in connection with the X-ray in the treatment of malignant disease. The

results already accumulated are too meager to establish a definite course of action for their employment in these cases. That the accessory measures have a beneficial effect upon malignant growths as well as upon the forms of lupus has been demonstrated to the writer's satisfaction. The evidence seems to be conclusive that all of the light rays of the spectrum violet and ultra-violet rays may be employed judiciously and with advantage in conjunction with the X-rays in the treatment of all cases of malignant disease.

The high-frequency administrations employing the glass electrodes with the coil or static machine, either in connection with or without a resonator or high-frequency step-up apparatus, are undoubtedly beneficial in some skin affections, as acne and lupus vulgaris.

Dermatitis, when it does occur, as it is certain to in all cases except when special precautions are taken, as in the treatment of acne, and the conditions in which it is used for its tonic effect, may appear in one of three types, which are similar to the dermatitis arising from other irritating causes. The condition has been well described by Beck, as follows: "The first is characterized by hyperæmia, infiltration, increased temperature, exfoliation in small scales, associated with a tormenting itching. It seems that there is a regressive metamorphosis (atrophy) of the differentiated elements of the skin, viz., glands, hair, and nails. The main feature of the second degree consists in the formation of blisters—the inflammatory signs are well pronounced, the tension considerable, and the pain intense accordingly. After the blisters are removed the corium is exposed as a red and sore surface—bullous form of Roentgen ray dermatitis. The third and gravest degree is characterized by the escharotic destruction of the irradiated tissues. They show the sign of dry gangrene, and appear brownish black. If they exfoliate by a slow suppurative process, or, if they are removed, as they should be, by surgical interference, a granulating ulcer remains, the cicatrization of which may take months—the necrotic form of dermatitis."

The indications when dermatitis occurs are in most cases to stop raying the tissues as soon as the first blush of redness

appears and to suspend treatment until it has disappeared. In the meantime, the case should be treated as an ordinary dermatitis with cooling applications. The writer has found the itching to be usually allayed by applications of carbolized vaseline. Later the irritated surfaces will be smoothed by the application of the officinal zinc ointment. Exposures of the surface for from twenty to thirty minutes daily to sunlight, or better, to the rays of a powerful arc light, projected from a parabolic mirror.

The deep X-ray burns may be considered in this connection, though they have occurred oftener with skiagraphy from carelessness than as a resulting condition of radiotherapy. The condition rarely occurs now since the action of the X-ray is so well understood, and only in cases when exposures have been made for periods of from thirty to sixty minutes, or for relatively long periods on successive days. It is characterized by the superficial third-degree dermatitis of the necrotic form and at the same time involves deeper tissues, often extending to the bone. In most cases in which the accident has occurred no screens have been employed, and consequently the tissues starting from the region which has received the direct rays at the shortest distance are devitalized in varying degrees back to the normal tissue. For this reason, a line of demarcation between the necrosed tissue and that which has just escaped necrosis is not formed for a long time and the reparative process is long delayed. Probably few conditions are more aggravating or recover more slowly than deep X-ray burns.

The indications are to assist nature in getting rid of the necrosed tissue, at the same time to sustain the vitality of the patient in every possible manner until nature has time to repair the damages done. It is far easier to prevent a deep X-ray burn than to cure one. It is rarely necessary to make exposures for purpose of diagnosis with the X-ray for long periods, for at the present time improved facilities enable the skiagrapher to shorten the period. When, however, exposures are made, as may be necessary with some apparatus, for periods of thirty minutes, care should be taken that a

second exposure should not be made within five days. Another matter to be taken into account is the physical condition of the patient, remembering that aged people and those whose vitality is reduced by sickness are more susceptible to the injurious effect than persons in good health.

It is also well known that low-vacuum tubes energized by either coil or static machine are more apt to cause these conditions than tubes of high vacuum.

Indications for the therapeutic employment of the X-ray may be divided into three distinct classes: (1) cases in which it is employed for its stimulating or tonic effect; (2) cases in which it is sought to destroy malignant growths without breaking down adjacent normal tissue, and (3) where it is employed for its effects upon regions of local congestion.

The cases included in the first classification are such as pulmonary tuberculosis, indolent ulcers, and alopecia areata. These features will be considered in the treatment of the subject under the management of the various classes of cases.

CHAPTER IV.

TREATMENT OF THE FORMS OF SARCOMA AND CARCINOMA.

The diverse views of various writers and authorities upon the methods of application of X-ray treatment to malignant disease arise probably from failure to recognize their peculiar actions upon normal and abnormal tissue, some having employed them without due caution and foresight. Others do not take into account the fact that the larger number of cases submitted to the present time have been hopeless, inoperable cases.

Experience taught those who made use of the X-ray immediately after its discovery that its action was dangerous to normal tissue.

What produced the destructive effect seems to be demonstrated by its action upon various conditions. It is evident, as previously shown, that protoplasm contracts when exposed to the X-ray—whether from the stimulating action due to the intense vibration or some other specific action of the rays, is not known. The contraction of the muscular structures of the circulatory apparatus at first lessens by giving tone and later completely occludes the lumen of the vessels to a degree in proportion to the extent of exposure, which varies with the condition of the ray, the character of the structures exposed, and the capacity of the blood-vessels. If the epithelial coats of the capillaries were not susceptible, having no muscular coats but the lumen of the smaller blood-vessels, were entirely occluded by the contraction of their muscular coats, the capillary circulation would also be interfered with.

The larger vessels are not occluded to the same extent, relatively, as the smaller, and the arteries deeply placed are affected relatively to the depth and intensity of the radiance. It seems also that in the intervals between exposures there is always a disposition for all of the structures to resume normal condi-

tions. Hence, in the longer intervals between periods of exposure, the arterioles gradually relax and resume their function and the tissues which have not perished are restored. Under the process of tissue change, induced by the X-ray, the cancerous tissue element will have perished while the normal structures recover.

The relative degrees of destruction of the abnormal tissue, and possibly of the normal tissue as well, or complete destruction of the abnormal and partial or complete restoration of the normal, will depend upon many elements which are variable: (1) the penetration of the rays of different tubes variously excited; (2) the relative vitality of the tissues; (3) the physical status of the patient; (4) the depth or thickness of intervening structures, (5) and the length, frequency, and distance of exposure. To obtain relatively satisfactory results will call for a degree of judgment, technical knowledge, and skill in the manipulation of apparatus which experience will improve, but never make perfect. With these facts facing the physician, he cannot fail to realize the responsibility of the undertaking in the treatment of these critical conditions.

The effect of breaking down a sarcoma or carcinoma, deeply seated or superficial, is to induce a degree of auto-infection which may imperil the life of the patient. When drainage is possible, except into the alimentary tract, in which absorption will invariably take place, the prognosis may be fairly good. Experience has taught that a malignant growth breaking down within or discharging into the alimentary canal is certain to be followed with dire results.

A tumor in the abdominal cavity may break down and discharge its contents into the peritoneal cavity and thus be followed by a fatal peritonitis.

It then becomes incumbent upon the attendant to weigh well every feature of effect and possibility of the results when treating an abdominal cancer. Wherever a malignant tumor, except one of small size, appears, the indications, if operable, are for its removal, after a period of raying consistent with the indications of the case, usually for periods of from four to six weeks.

Preoperative raying is a subject deserving most thoughtful consideration. Experience teaches those who have observed the action of the X-ray upon a case of recurrent cancer of the female breast, that the processes are abated, the tumor becoming movable over the underlying structures, the pain is diminished, and, at the same time, undoubted removal of some of the foci of infection and in some cases apparently all such foci takes place.

The indications for the application of the X-ray prior to operative procedure in all cases of malignant disease are: (1) to remove the surrounding infiltration, permitting the tumor to move freely over the underlying structures, and at the same time lessening the activity of the malignant process; (2) the destruction of surrounding foci of infection; (3) to prevent infection and consequent recurrence in the line of the cicatrix, where from past experience it is shown to almost invariably occur.

The disadvantages which may arise from raying before the operation are, (1) a possibility of lowering the vitality of the skin which may defer the prompt union by first intention, and (2) the possibility that a delay, owing to the rapid growth, even when rayed, may militate against the ultimate recovery of the case.

The removal of the infiltration surrounding the congested area is acknowledged, even by those who do not recognize the importance of preoperative raying, and requires no defense. The statement that foci of infection are destroyed is undoubtedly correct, because epithelioma and other growths of known cancerous nature are removed by the systematic employment of the X-ray, even beneath the integument, and because of the remarkable improvement in most cases. The importance of raying to prevent recurrence in the line of the incision is too apparent to require discussion.

The disadvantage of delaying union, due to the lowering of vitality, while possible in some instances, is not of uniform occurrence, and even if it should occur, does not necessarily contraindicate the procedure. With reference to the possible danger arising from deferring the operation, it is needless to

say to those familiar with the employment of the X-ray that the danger is an exceptional one, because the malignant growth is in most cases at once adversely affected by the exposures of the ray.

It seems from these observations that there can be no indication or argument against the wisdom of the employment of the X-ray for a period preceding the operation in most cases.

The removal of the glands in the region of a malignant growth which have not become involved, is contraindicated for two reasons: (1) that the glands have functions to perform; (2) that their presence is a bar to immediate metastasis in case of recurrence. Under judicious observation, following the operation in cases in which the glands have not been removed, they will serve constantly as objects for investigation, their enlargement indicating recurrence at the original site earlier than might otherwise be determined.

The X-ray, in many such cases, when applied early, will restore the parts to normal, for an enlarged gland in proximity to a malignant process is not necessarily an infected one, and when under X-ray treatment, such a gland has been repeatedly known to become normal and remain so for long periods or indefinitely.

The reaction which occurs at varying periods during the course of X-ray exposures is marked by different degrees of intensity, varying with the conditions rayed. It undoubtedly arises from auto-infection due to the breaking down and reabsorption of toxins. This reaction is associated with degrees of fever and depression ranging from a slight malaise, which often is not detected, to a profound depression sometimes accompanied by high temperature and great prostration. The condition, however, is not a dangerous one nor one to be feared, except when raying internal cancers, which are not provided with external drainage, or in cases calling for protracted treatment. Symptoms may appear, as they have in one case in the writer's experience, on the day following the first exposure or be deferred for several days. In cases which are rayed for considerable periods the condition will as a rule occur at some time during the course of treatment. In most cases, however, the reaction comes on gradually, persists during the sloughing periods, and subsides during periods of rest.

Auto-infection from the absorption of broken-down tissue should not be confused with metastasis, because in no instance, in the writer's experience at least, has metastasis been occasioned by the process of auto-infection, which, as considered above, will persist with varying degrees of intensity during the period of disintegration of the malignant mass.

Metastasis has been attributed to the Roentgen ray by numerous observers, generally those who are opposed to its employment. There are many reasons, we believe, and experience teaches, that these occurrences are coincident, and do not result from the actions of the ray. The vibratory influences of the X-ray, to which alone such effects could be attributed, are not of the gross character which affects masses of tissue in a manner which could produce metastasis. It must also be remembered that the cases that have been submitted to the X-ray treatment have been inoperable, many of them in advanced stages of the disease. Under such circumstances, metastasis should not be looked upon as an unusual occurrence. Furthermore, the larger number, if not all, of these cases of metastasis have occurred in recurrent, inoperable cancer of the breast in which the glands had invariably been removed. It is a well-attested fact that the glands check the extension of infection, and that when metastasis does occur in these cases, as it is likely to, it is in remote regions which might have been spared had the glands not been removed. It is, therefore, impossible from the present history of the use of the X-ray in malignant disease to draw any positive conclusion which will show, without question, that metastasis is induced where it would not have occurred if the X-ray had not been employed.

Those most familiar with the treatment and course of malignant disease with the X-ray will cordially concur in these statements.

The effects of the Roentgen ray on carcinoma and sarcoma

are in so many respects the same that they will be considered together. The disintegration of malignant growths is always relative to the vitality of the tumor in question. No two cases of sarcoma or carcinoma of any of the types are influenced in exactly the same manner by the same character of exposure. It is a question of nutrition, which will vary with the health and vigor of the patient and the proximity of the growth to large sources of blood supply. In debilitated patients, fortunately, the tumors break down from less vigorous treatment than in the robust; otherwise, the normal tissue would be sacrificed by the influence of the X-ray. It has been shown from past experience that sarcoma responds more promptly to X-ray treatment and promises a better prognosis than carcinoma, other things being equal, which is probably due to the lower vitality of the structure of the former; otherwise it is difficult to determine any special variation of the effects other than that dependent upon the general nutrition of the patient and the location of the lesion.

It will not, therefore, be the purpose of the writer to consider malignant disease from the standpoint of particular types of cancer, but with reference to the general character of the structure and the location of the lesion. Two classifications of structure only will be considered relatively, i. e., bone and soft tissues.

Malignant disease of the bone promises little encouragement from the X-ray treatment alone. To the present time, we believe, there are no cases on record where a sarcoma or carcinoma of the bone has been cured by the action of the X-ray. There are many cases, however, in which the effort has been made to save bony structures, and the life of the patient has been prolonged and the conditions somewhat improved for varying periods of time, but in no case is there a record of cure. It seems to be demonstrated that the action of disintegration in the vascular structure of the bone is less influenced by the action of the X-ray than in that of the soft parts, but that the growth is retarded, with a disposition to break down and discharge, as is evidenced in the cases which have been observed. It is found impossible in these cases to

sufficiently disintegrate the hard substance and remove a sequestrum of bone, as under ordinary conditions of bone necrosis. The indication, therefore, in all cases of malignant disease involving the bone is its surgical removal. In these cases, then, the same rule should be applied as in the treatment of all malignant disease. The region should be rayed with a high-vacuum tube for a period of from four to six weeks before the operation, and the diseased bone removed. Following the operation, it should be again rayed and watched, and the same cautious care should be observed as is exercised in the treatment of all cases of malignant disease.

Cancer of the soft structures will include all other cases except those involving bone, and call for no special consideration.

The local classification will be made with reference to the region affected, as follows, (1) face, (2) throat, tongue, and fauces, (3) breast, (4) internal, (5) uterine, (6) vesical, and (7) rectal. Epitheliomas will be considered in the subsequent chapter under Diseases of the Skin.

Cancer of the face may arise pathologically in the deeper structures including the bones or extend from an epithelial growth upon the surface, and later involve deeper structures. There are no special indications for the treatment of cases not included in the general consideration of the subject. As has been said, when the bone is involved the indications will invariably be with a view to an ultimate surgical operation and subsequent raying. When the orbit is involved in the process, it should be rayed with the same exposure as the other structures, and experience has taught that the eye in most cases is not unfavorably susceptible to its influences.

In the case shown in Figs. 4, 5, and 6 the eye was subjected to X-ray exposures during ten months of consecutive treatment, and suffered no harm until the disease had involved the organ from behind the orbit.

An interesting case of sarcoma of the face which was referred to the writer by Dr. W. B. Coley was a subject of great interest to the writer, and demonstrates so many valuable lessons that it will be considered at length. The patient, Dr.

L., dentist, aged thirty-six, was in perfect health until July, 1900. The first symptom was an excessive flow of tears from the left eye, and then inability to breathe through the left side of the nose, and loosening of a second molar tooth on the same side. Soon a small elevation appeared on the contiguous surface of the gum and hard palate not unlike a "gum-boil." Not yielding to treatment, it was diagnosed by several surgeons to be a sarcoma, and removal of the greater part of the superior maxilla was advised. The operation was performed by Dr. W. T. Bull on September 21, 1900. The recovery was prompt, with very little deformity and no impairment of speech, and the scar was hardly noticeable. There was recurrence, and a secondary operation was performed again by Dr. Bull on February 4, 1901. The serum treatment advised by Dr. Coley was proposed, and the patient put under Dr. Coley's care. This treatment was administered systematically with the usual reactions until June 1. The interior of the mass was then curetted and the serum treatment continued. The growth was kept in abeyance until August, 1901, about one year after the first appearance of the growth. After August the growth progressed rapidly, involving the tissues along the scar, extending through the left cheek, left part of nose, and displacing the left eye considerably. Until this time there had been but little pain in connection with the pressure, but the pressure on the eye then caused considerable discomfort, accompanied by headache. At the suggestion of Dr. Coley an attack of erysipelas was induced early in the month of November. 1901. It lasted with remissions for about three weeks. The results were very striking. The tumor flattened considerably. The masses of malignant tissue of the nose and the eye were almost restored to a normal condition. There was, however, considerable sloughing, accompanied by foul odor. The end of this induced erysipelas marked the end of improvement. The tumor returned to its former size, and then involved the adjacent parts, crossing over the median line, and causing increased thickness on the right side of the face under the eye. Other inoculations of erysipelas were made, but failed to have any effect, the patient evidently having become

immune. At this time the general health was weakened, pain was almost continual, accompanied by severe headaches and sleepless nights. The opening on the left side of the nose in

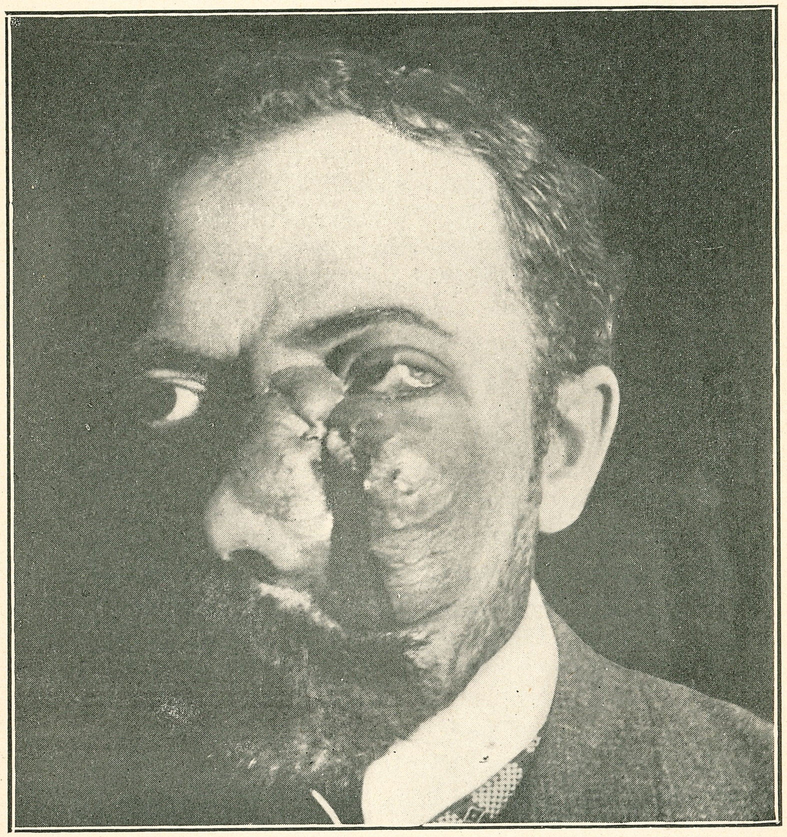


Fig. 4.

the line of scar was accompanied by more or less sloughing. At the suggestion of Dr. Coley the patient was then referred to the writer; and on January 15 the first X-ray exposure was made. On the following day the photograph shown in Fig. 4 was taken. It will be observed that there was a tumor five inches long and four inches wide, which also had a

depth of four inches, as estimated by the patient, from the nearer to the outer surface at the longest diameter. The nose and angle of the orbit were the sites of small tumors and large superficial veins ran across to the opposite side of the nose. A tumor of considerable size will also be observed in the cut on the outer canthus of the eye. The first two exposures were each of twenty minutes' duration and administered on alternate days. The large engorged veins which ran across the front of the tumor became dry, and were removed like pieces of burnt wood, leaving depressions but not bleeding holes. The slough and discharge, which were considerable and offensive at the commencement of the treatment, disappeared. The exposures were made, after the first two prolonged ones, for ten minutes each on alternate days, and high-vacuum tubes were employed. After three or four exposures a marked change for the better was noticeable. The discharge and slough had diminished, and the displacement of the eye had become less marked. The pain was much less, being absent sometimes for days, and the patient's general condition had greatly improved. The size of the tumor was rapidly reduced, as shown by a photograph taken one month after the first exposure (see Fig. 5). During the subsequent progress of the treatment, many features interesting to the study of radiotherapy developed. The tumor upon the orbit, as it appeared in the first photograph, absolutely disappeared during the first month of the treatment. From time to time, during the course of treatment, the patient had marked reactions associated with the sloughing away of the large tumor of the face from beneath the surface and later from sloughing elsewhere. During these periods symptoms of auto-infection were present, and marked by various degrees of fever and depression. The improvement of the local conditions progressed rapidly. There was during the first months of treatment frequent disposition of the disease to extend to the maxilla of the opposite side, which was evidenced by loosening of the incisors, swelling of the gum, and tenderness during mastication. Whenever these symptoms occurred after several days of vigorous raying with high tubes, the tenderness and

swelling would subside to return later. From time to time this condition was checked and held in abeyance until a period of about seven months after treatment had been instituted.

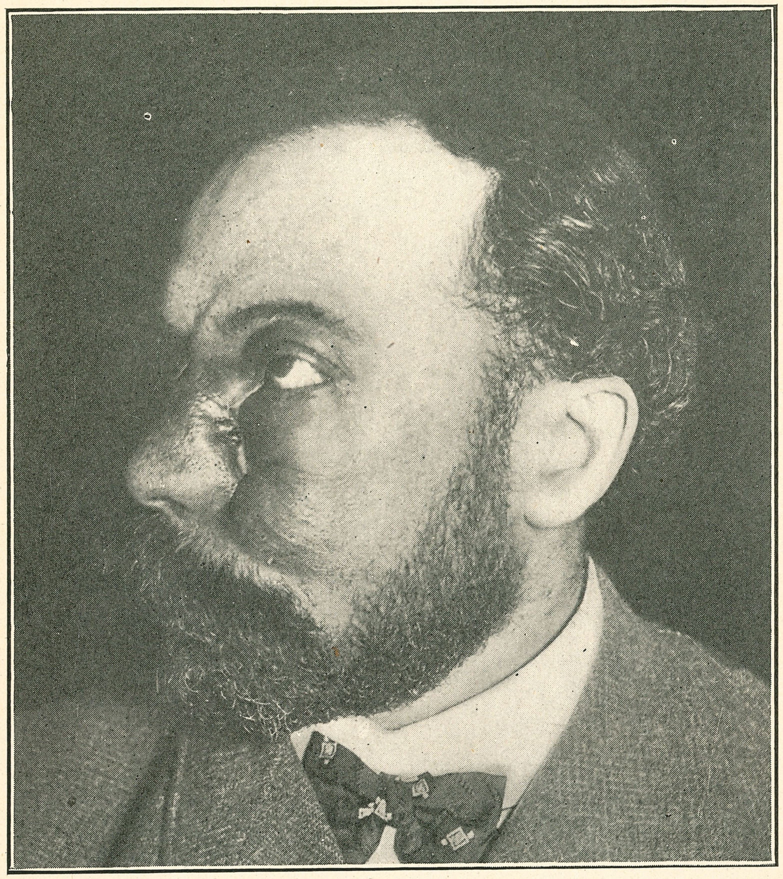


Fig. 5.

The progressive disappearance of the tumor and constant improvement of the facial deformity were marked until about five months after treatment was begun, when the tumor had absolutely disappeared never to recur during the life of the patient, as shown in Fig. 6. The orbit occupied relatively its

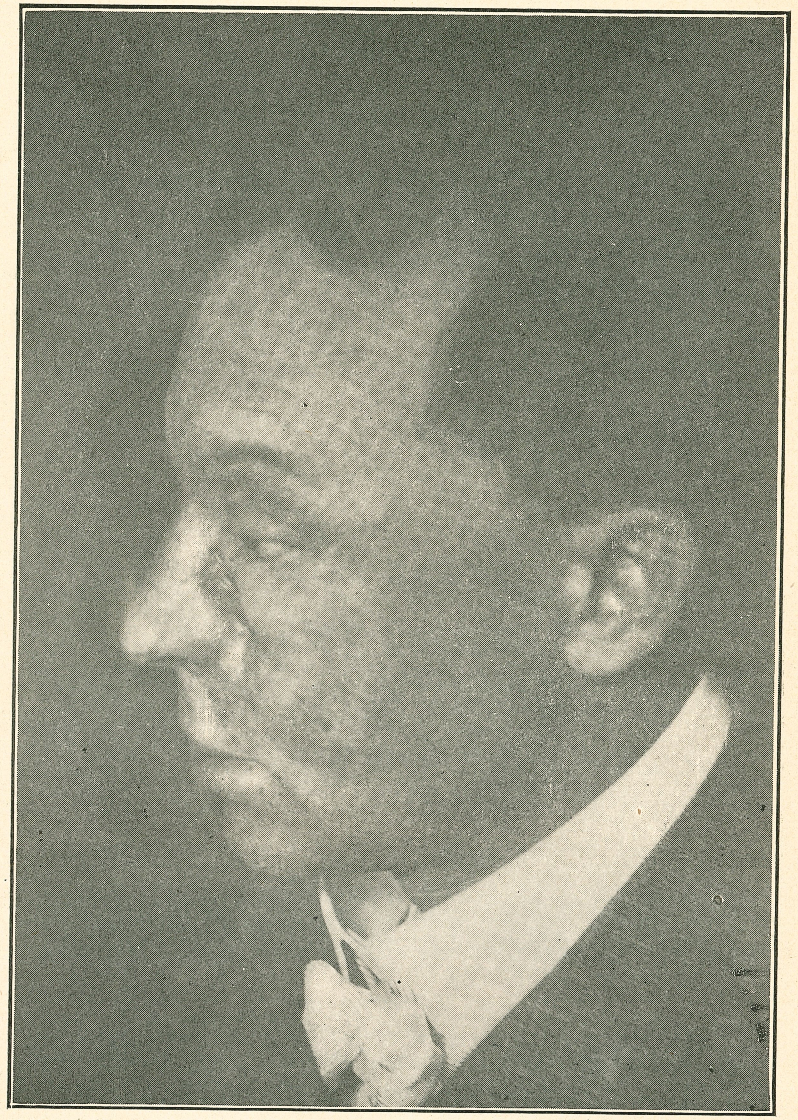


Fig. 6.

normal position, except that there was a slight protrusion forward. Immediately following this improvement, however, there was evidence of the progress of the disease in the pharynx and post-orbital region with severe pain and pressure, of which the patient complained most bitterly during the last months of his suffering. The disease extended inward through the bones, in which it had gained a foothold before the first exposures of the X-ray were administered. The process extended inward and involved the structures at the base of the brain, finally terminating in the death of the patient in the month of November, 1902. Before death the orbit had become again involved with a growth which protruded from beneath the lid and surrounded the margin of the iris. It should be said, however, that during the latter months of the patient's life he was unable to submit to X-ray treatment for periods of weeks consecutively on account of the painful dermatitis, he having become more susceptible to the X-ray during the progress of the treatment. The involvement of the opposite side during this period also became more marked, but at no time prior to his death was there any recurrence of the tumor in the soft parts upon the opposite side. Metastasis did not occur in the history of the case.

This case demonstrates many valuable principles of the effects of the X-ray upon living tissues. (1) That tumors which involve the bony structures will not yield satisfactorily to exposures of the X-ray; (2) that large tumors will disappear by sloughing within the mucous cavities when rayed over the integument; (3) that the process of sloughing is invariably associated with rise of temperature and depression due to auto-infection, which does not, however, lead to metastasis; (4) that marked progress toward improvement takes place during periods of depression; (5) that with physical improvement in the general condition of a patient there is apt to be a more vigorous extension of the processes of the disease—possibly a coincidence; (6) that for most marked results, X-rays having great power of penetration are indispensable in the treatment of such cases; (7) that with great caution and raying every second day for ten minutes, dermatitis of the second

degree is very apt to follow, as it did in this case four times during the course of the treatment; (8) that necrosis of nor-

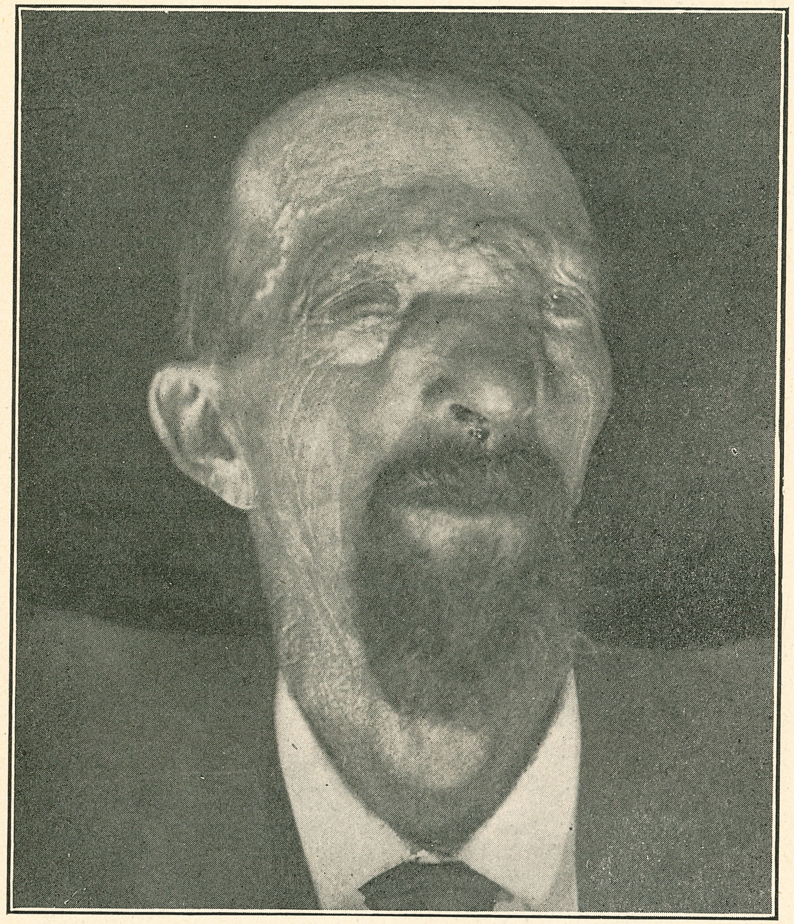


Fig. 7.

mal tissue does not occur under the last-named conditions if raying is discontinued; (9) that patients become less tolerant to the rays during prolonged courses of treatment; (10) that

long periods of time are essential in some cases to effect a cure or determine a failure.

Another case is shown in Figs. 7 and 8, which is evidence of the remarkable effect upon the superficial structures in cancers

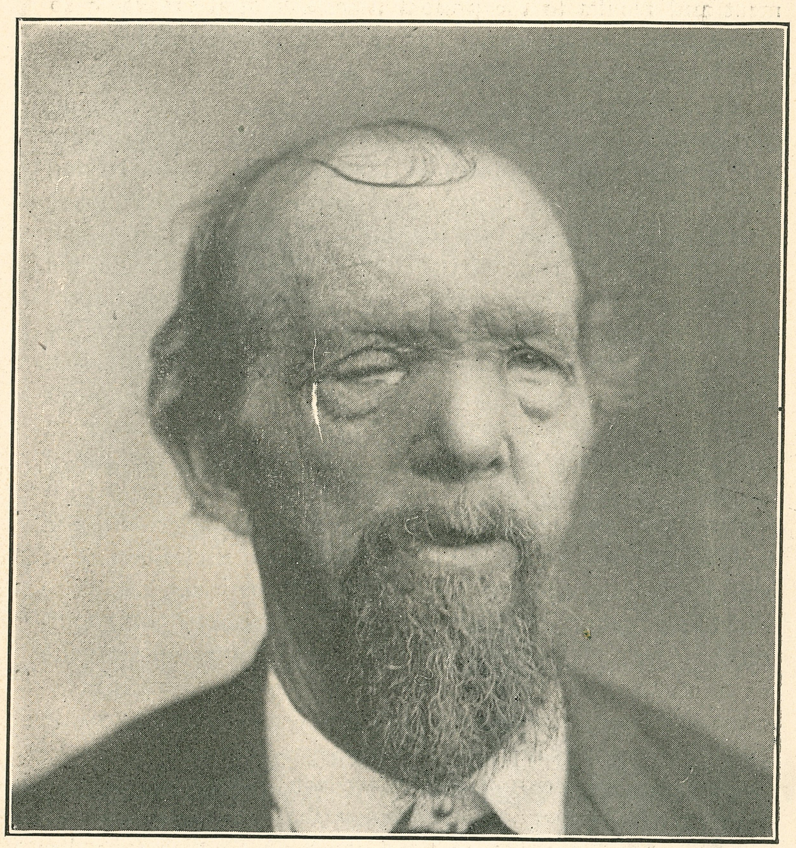


Fig. 8.

of the face. The patient, Mr. T., was referred to my clinic by Dr. Sharp with diagnosis of adeno-carcinoma, involving the turbinated bones and other structures in the posterior nares. The first photograph was taken on the day following the first exposure, and the other at the expiration of five weeks with the

result as shown. The prognosis in this case, however, which is still under treatment, is unfavorable, as in all cases in which the bones are involved.

Cancer of the larynx, according to the records of treatment and results to the present time, has been favorable so far as partial or temporary improvement is concerned, but in most cases the final results have not been so favorable as would be hoped. The difficulties to overcome in making exposures to the larynx are due to the intervening cartilages and possibly other features in the structure of the larynx, which necessitates a degree of exposure which, when made over the larynx, seriously affects the skin before sufficient improvement can take place in the involved organ. Marked improvement, however, takes place in these cases, life is prolonged, and success has been reported at least in one case.*

It is necessary in these cases to employ all the means at command to meet the difficulties. For this reason, exposures should be made both over the throat externally and by a special X-ray tube directed into the larynx. The method of exposure externally may be made as follows:

Secure a metal shield to the margin of the lower jaw, tied back of the head to cover the face, and the composition chest shield for protecting the trunk. In these cases, exposure should be made with high-vacuum tubes placed with anticathode ten inches from surface for ten minutes on alternate days, and pushed to the extent of producing dermatitis, because it is necessary, in order to affect the deep structures, to employ the rays as intensely as the tissues will permit.

An accessory measure, and one which will add to the possibilities of recovery, is to employ the X-ray through the mouth. A modification of the Cossor, an English tube, has been designed by the writer, and is found to be convenient. Surrounding the prolongation of the tube (see Fig. 9) is a shell of glass open at the extremity, which insulates it by an air-gap between the tube and the shell. By this means it is possible, with the additional insulation of a piece of rubber tubing, to

* "A Case of Cancer of the Larynx Cured by the X-Ray," by Dr. W. Scheppegrell, in the Journal of Advanced Therapeutics for December, 1902.

place the tube well into the mouth, whereas without the glass insulation the induction will carry the discharges through a very thick insulation of rubber tubing, making it impossible to employ the tube in this position. The exposures may be made with this tube when the static machine is employed for periods of ten minutes. The distance should be measured by the space between the anti-cathode as in all cases. It must be borne in mind when employing these tubes, which are made of lead glass, that only a beam of X-rays, measured by the area

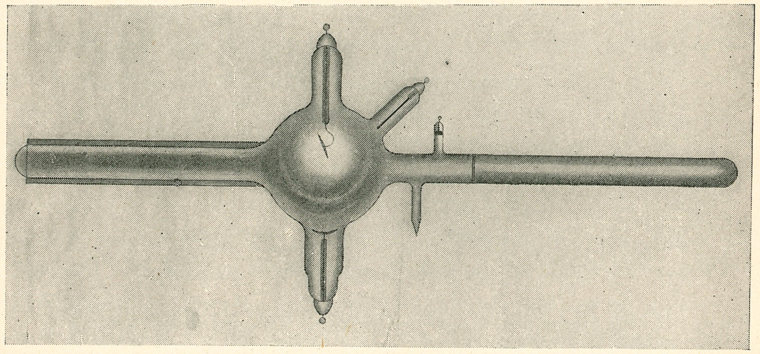


Fig. 9.—Modified Cossor Tube.

of a transverse section of the extension, is projected in the direction of the prolongation. It is, therefore, essential that the operator shall know the exact position of the tumor, and place the tube at the angle which will direct the rays to it. It is not prudent to use the medium-vacuum tube in this position as an accessory oftener than twice weekly for ten minutes at ten inches, for though it is demonstrated that the mucous membrane is no more susceptible to the influences of the Roentgen ray than the skin, the location makes caution imperative.

Patients should be impressed at the commencement of treatment for laryngeal cancer that the treatment is certain to be a prolonged one, because the action of the X-rays upon cancer in this position is in most cases, especially true of carcinoma, in effect very slow. At this time, the record of improvements

in the cases treated is sufficient to urge the employment of the method, but not sufficient to show any positive results. It will, therefore, be best in all cases to give a guarded prognosis. One case which the writer had under observation for nearly one year made progressive improvement, but very slight, for months, when an intercurrent sickness kept the patient from treatment for a period of six or eight weeks; after which time the improvement was less marked, and, finally, recurrent attacks of dermatitis delayed the treatment again, and the case became gradually worse. During the early treatment of this patient the special tube described above was not in use, and, with one used during the later months, so much trouble was experienced from the discharges to the teeth of the patient that he became timid. This led to the adoption of the tube provided with an insulated shell referred to. The patient, however, abandoned the treatment after six months, was treated by mechanical vibration for about six months, and subsequently died from an intercurrent disease without further progress of the throat affection. The susceptibility to dermatitis, which had become so painfully marked in this case, demonstrates again the unpleasant feature of long-continued employment of the X-ray. The interference occasioned in the progress of the treatment which, in many cases, is for long periods, so far militates against the success that the patient may eventually abandon the treatment, and a fatal result subsequently follow.

It is the writer's conviction that even in these cases when it is possible that an operation following a period of raying promises so much in the ultimate success of the case that it should always be given serious consideration.

Cancer of the tongue, we believe, is one of the conditions in which the X-ray is especially indicated. It has been shown by one writer that those cases do the best in which no operation has been performed. In these cases, however, it is probable that the operation had not been preceded by a course of preoperative exposures to the X-ray. The technique to be employed when the growth is near the tip of the organ is to protrude the tongue for purpose of exposure through an

opening in a screen placed upon the face. Another method, which may be employed with a tumor on any part of the tongue, is to make use of the X-ray tube designed for internal treatment of cancer of the throat described above (Fig 9). If the tumor is small, exposures made over the organ in this way would effectually cover the portion exposed; otherwise, the portions of the mouth to which the rays are not directed may be protected by fitting tin over the vault and sides of the fauces.

Cancer in other parts of the mouth, as the pharynx or postnasal regions, may be treated with a jacketed cavity tube provided with a shield of tin, which shall cover either the water bath or the inner glass of the tube, except where the rays are to be emitted. In this way, the rays may be directed to any part. The prognosis in these cases, however, will depend upon the limited area involved. It is probable that in no case where bony tissues have been invaded, except they are first removed, can anything but an unfavorable prognosis be given. Here, as in other cases, surgery and the X-ray must work hand in hand.

Cancer of the female breast, the most common of all types of malignant disease, offers to-day under the judicious employment of the Roentgen ray and surgery the greatest measure of success to the combined method.

Many surgeons are still loath to employ the X-ray before operation, and generally insist upon the removal of the portions of the pectoral muscle and all glands within the axillary region. This, we believe, is a radical mistake, and one which in future practice will be abandoned. First, because the services of the glands in case of recurrence are invaluable for the prevention of metastasis. It is well known that when in the past history of this operation the glands and all structures in the region of the tumor were removed as in desperation, almost certain recurrence took place, and the mortality of the disease was remarkable.

The treatment of these unfortunate women by combining the X-ray with the surgeon's knife in the management of all cases, making use of pre-operative and post-operative raying,

promises an ultimate lessening of the terrible mortality recorded in the past history of these cases. In no instance, we believe, should an effort be made beyond a period of six weeks to remove a cancer of the breast without surgical interference. On the other hand, prior to every operation, as has been previously shown, every case should be exposed to the ray for at least four weeks on alternate days, and immediately after union following the operation again for a period of at least six weeks. In cases in which union is delayed for any reason X-ray exposures will in many cases hasten it.

The established practice of operating upon these cases and removing the gland and portions of the pectoral muscle has been almost uniformly followed by recurrence within a short time after the operation. In few cases, indeed, has recurrence been delayed longer than three years.

Recurrent cancer of the breast is the condition to-day which most commonly faces the radiotherapist, either because the case is already an inoperable one or the prognosis is so unfavorable that the surgeon is disposed to refer the patients for X-ray treatment. The record of improvement and final recovery in these cases is not all that could be hoped. Temporary improvement is invariable, but at the time that the patients come under observation in most cases the disease has probably involved unsuspected regions, and during the improvement of the local condition the evidences of metastasis assert themselves, and the case is then beyond hope of recovery. In these patients it is reasonable to believe that had the lymphatic glands been left at the early operation they would have given warning of the recurrence before an extension into other regions had taken place, and at the same time might have checked such extension.

To the writer this seems a most important matter, and it is encouraging that a careful investigation is being made in accordance with these ideas.

The method of making exposures in the treatment of cancer of the breast is one which calls for thoughtful consideration.

In the early days of the employment of the X-ray the fear

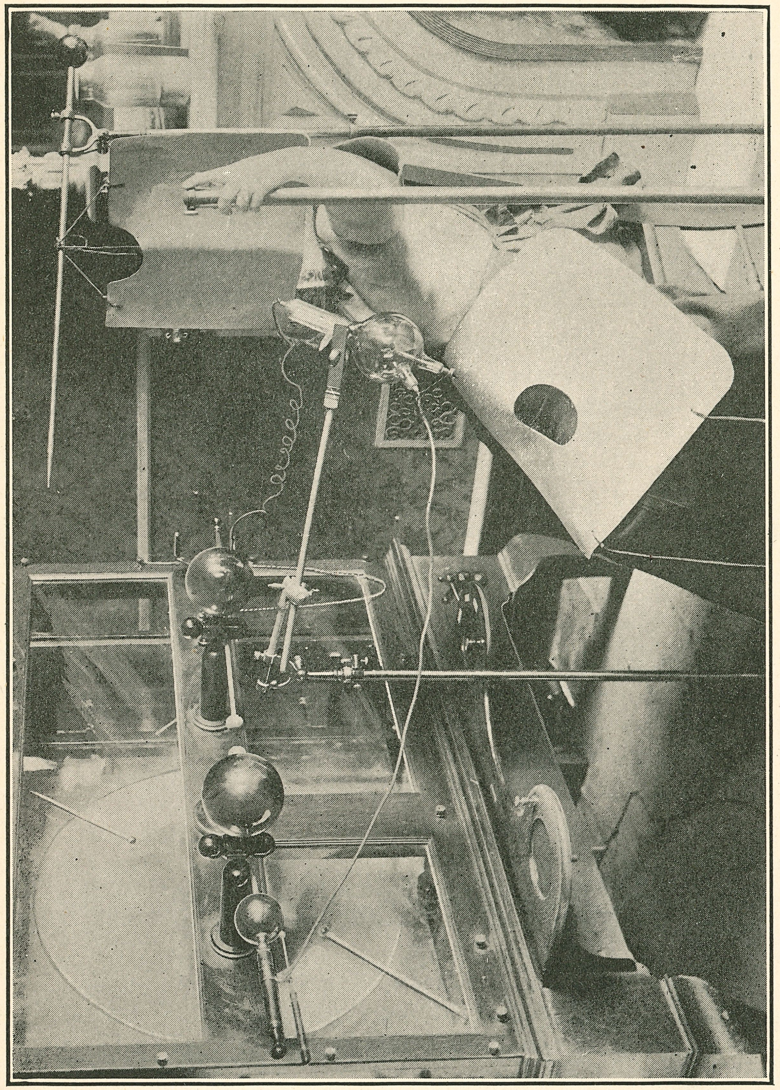


PLATE IX.—Method of Shielding when Administering the X-Ray in Cancer of the Breast, the Face and Arm Screened by Rubber Composition Screens. Tube Ten Inches from Side and Plane of Anti-cathode Parallel to the Surface Rayed.

of producing extensive dermatitis induced the employment of screens to an extent which often covered tissues already infected. It has since, however, become the practice to make wide and extensive exposures in these cases.

The writer has adopted an invariable plan of raying from two positions at each treatment. The first exposure, as shown in Plate IX., is made over the site of the operation with the plane of the anode opposite and parallel with the scar—only screening the face, the arm of the patient, and the abdominal region, permitting the oblique rays to come in contact with the breast of the opposite side.

Exposures so made will never produce dermatitis, except at the parts directly in front of the anode and nearest to the tube at the time of exposure. The second exposure is made with the tube placed at the back and the side of the patient with the anode directly towards the axillary space, the arm being raised, extended, and supported, and at the same time screened. This *modus operandi* includes nearly all of the tissues of the chest of the patient upon the affected side in the field of radiation, and especially those most likely to become affected.

As in other cases of malignant disease, the best results are obtained in the writer's experience from exposures made for ten minutes on alternate days, discontinuing the treatment upon the first appearance of a dermatitis and then resting the case until the skin has become normal. This procedure is followed by the best results for two reasons. The results of the ray carrying the effect to the extent of almost breaking down the normal tissue destroy the abnormal tissue cells and short periods of rest enable the tissues to recover, when normal tissue replaces the broken-down structures.

The following case, referred to the writer by Dr. Griffith Davis, will illustrate come important features of the treatment of cancer of the breast. Mrs. H., aged forty-six, came with a tumor in the left breast, about two inches in diameter, freely movable, and characterized by the usual early symptoms of carcinoma, sharp pain, commencing retraction of the nipple, and the glands slightly enlarged in the axilla.

The patient wishing to avoid an operation, a series of X-ray exposures were made. The raying was kept up regularly, except when resting the case during periods of dermatitis, for more than four months. During this time the tumor was reduced in size about one-third. The retraction of the nipple disappeared and the glands in the axilla, with one exception, became normal. At this time the patient developed a frequent pulse and other symptoms which induced her to yield to advice and submit to an operation. The breast was removed by my associate, Dr. Herman Grad, and the glands with the exception of one were left in position. The pectoral muscle was undisturbed and the patient made a rapid recovery. Subsequent to the operation, X-ray exposures were made on alternate days for four weeks, since which time the raying has been somewhat irregular, but the patient is still under constant observation fourteen months since the operation, with no indication of recurrence or affection of any of the glands.

The recurrent cases treated by the writer all made satisfactory progress at first, but in three instances metastasis later occurred; all were advanced cases and inoperable. All, except the one described above, have been cases of recurrent carcinoma, in which the glands have been removed, and the results, except in the three referred to, have been satisfactory.

The internal cancers, including those within the trunk proper, are usually in positions which afford no opportunity for drainage, and are therefore fraught with danger to the patient and a source of great anxiety to the physician who appreciates the dangers involved.

Few cases of success in the management of this class of cases have been reported to the present time. At best, the prognosis is unfavorable in all cases, but the X-ray offers such a measure of relief from suffering and the only possible hope in so many cases that its judicious employment should be encouraged.

The exposures should be made with relatively little screening of the trunk, and preferably a high-vacuum tube should be employed, because the skin is less apt to be affected when

the same degree of effect is produced upon the internal structures as would be produced by a low-vacuum tube pushed to a sufficient degree of penetration to affect the involved structures to the same extent. Exposures should be made in all cases not oftener than on alternate days, watching carefully the patient's physical condition, and standing ready to lessen the frequency or diminish the intensity of the treatment upon the indications of the dreaded auto-infection, which may at first be slight, marked by progressive decline in the patient's general health, with lost appetite, slight fever, and varying degrees of prostration. In these cases, the lowered condition of the patient should not be mistaken for a possible extension of the diseased process, because the patient's health would not be likely to be impaired in so short a time by an extension of the disease beyond what had preceded the period of X-ray exposures.

To discriminate, however, is a matter of the utmost importance, because, should the employment of the X-ray be pushed to the point of breaking down of the malignant mass, a mild degree of auto-intoxication would merge into a condition of severe prostration likely to be followed by unfavorable results.

Bearing in mind that the action of the ray is to break down malignant tissue, it is of the utmost importance that the exposures be made with great caution and that in each case the size and location of the tumor be considered. While, under ordinary conditions, when an abscess breaks into the intestinal tract not sufficient infection takes place to endanger the health of the patient; with the broken-down cancerous structure, however, it is different—evidently from the toxins which are the products of the destructive action upon the malignant growth. These poisons require most careful consideration, and their rapid absorption must be prevented or the life of the patient may be shortened by the process of treatment.

It will be wise, therefore, noting the condition of the patient, not to be governed alone by the degree of dermatitis in determining the limitation of the exposure. As soon as the first lowering of the physical status of the patient appears,

the frequency of the exposures should be shortened or the tube placed at a greater distance from the surface, and the case carefully watched and given occasional periods of rest from the treatment. On the other hand, it can be easily understood that too great conservatism in the process of raying may eliminate the possibility of curing a patient, because if the periods of rest are too long or the treatments not sufficiently energetic, the disease may be held in *statu quo* for a time, but not cured, and ultimately the lowered condition of the patient be followed by general decline and death. Cases which have made satisfactory improvement have, in a few instances, been those in which the raying was carried to a dangerous limit.

One case reported to the writer by a confrère had been rayed for a cancer of the cæcum until a dangerous degree of auto-infection was induced. The patient lay for many days at the point of death, but finally rallied and is clinically cured. It will therefore always be a hard question to determine, how far this process should be carried in order to effect an ultimate cure. The individuality of the case has much to do in governing the procedures, and experience only can teach this valuable lesson, and at best many accidents will occur in skilled hands, which might have been otherwise, had a slight change been made in the conduct of the case.

It is impossible to give any definite rules of action. Good judgment, foresight, and experience will increase the number of successes in this otherwise hopeless class of cases. It may be said, however, that the patient's life, which may be shortened, under these conditions, will fortunately be somewhat relieved of suffering in the employment of another effort for recovery.

The physician who would protect his own good name when treating cases of internal cancer must be open and candid at the outset in explaining the possibility of accidents and should always give a most guarded prognosis, as favorable results can be obtained in but a small percentage of cases of internal cancer.

Cancer in the pelvis offers more favorable results than the

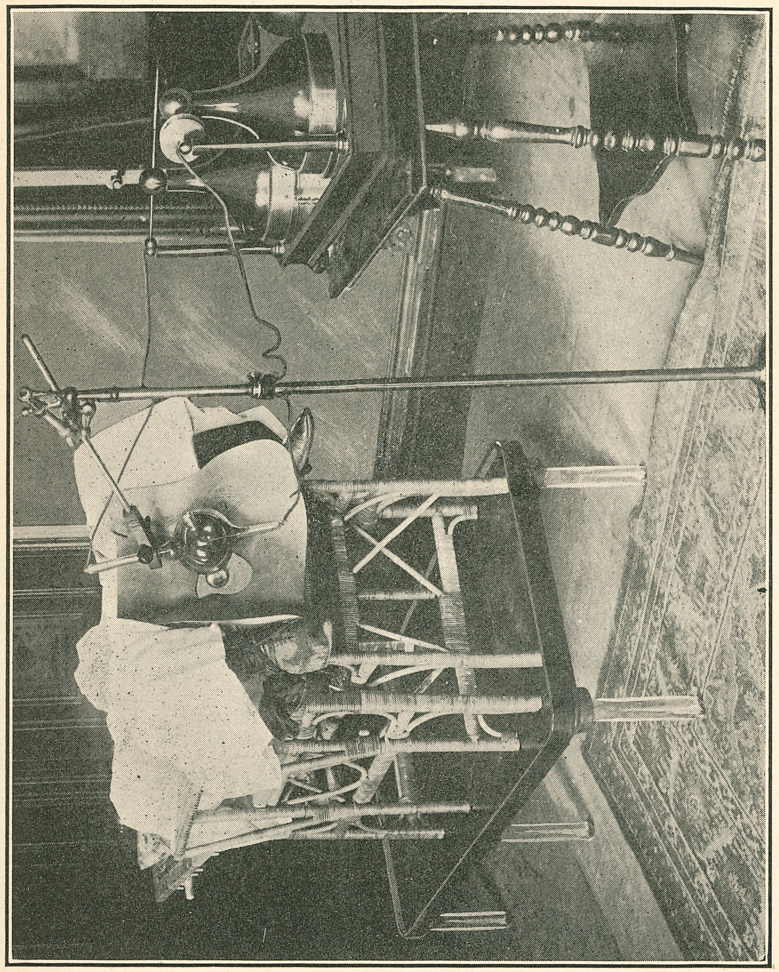


PLATE X.—Method of Raying through a Speculum, Soft Rubber Shield Cutting off the Rays Laterally from the Limbs of the Patient, the Speculum Surrounded by a Shield of Soft Metal or Rubber, High-vacuum Tube Anti-cathode Perpendicular to a Line Passing to the Affected Parts.

preceding class of cases, because of the obvious advantages of drainage.

Cancer of the uterus is a condition which the advent of the X-ray in therapeutics offers a most hopeful prognosis. The results already promise great alleviation and clinical improvement in all cases, and we believe, properly associated with the surgical procedures, it will be possible to cure very many of these cases. It should not be sought in any instance to preserve any portion of the organ in question, placed as it is

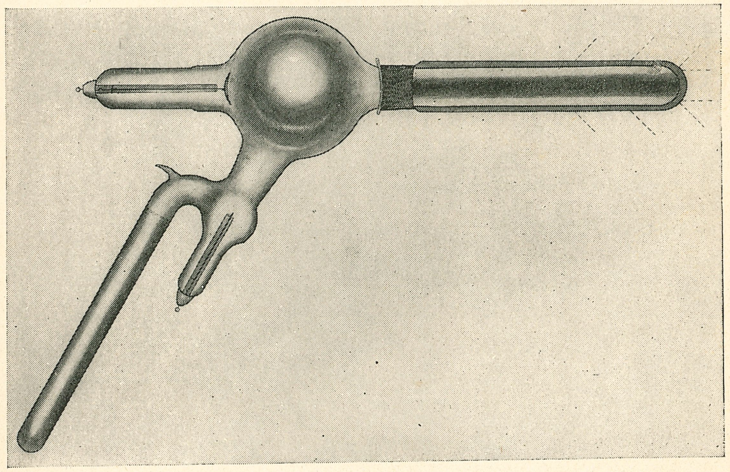


Fig. 10.—Jacketed Cavity Tube.

adjacent to other structures which may become so easily involved by a possible recurrence.

In the treatment of these patients, preoperative raying is a matter of the greatest importance, as will be shown. This procedure should be carried out thoroughly for from four to six weeks, the exposures to be made either from below through an aluminum speculum, as shown in Plate X., or employing the jacketed cavity tube, Fig. 10; or a Pennington shield, Fig. 11; or a modified Cossor tube, Fig, 9; or by raying immediately over the coccyx. Another exposure should be made with a high-vacuum tube placed over the abdomen at a

distance of eight or ten inches with the plane of the anti-cathode perpendicular to the axis of the superior strait, that the larger volume of rays may be projected downward through the pelvis. (See Plate XI.)

The method of screening during this procedure is simple and effective. Place a large screen of rubber composition (Fig. 1), or a tin one, having a hole about five inches in diameter in the center, in a position that will permit the rays to pass as suggested. It will be generally unnecessary to employ any other screen in these cases if the one employed is

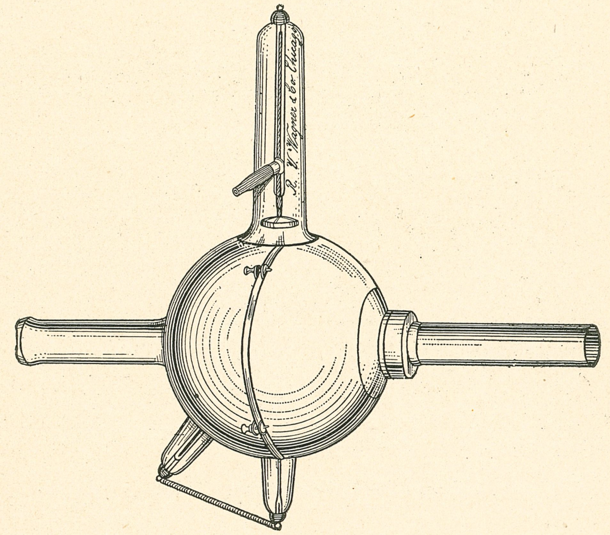


Fig. 11.—The Pennington Shield.

eighteen to twenty-four inches in dimension, if the head be slightly elevated, as the position of the anti-cathode will direct the rays from the upper portion of the abdomen, and the thighs will not be near enough to be unfavorably affected.

When raying at the perineum the same rubber shield may be employed, securing it to the thighs by cords, and fitting within the opening smaller shields to cover the parts not necessary to expose, as shown in Plate X.

If the jacketed tube, Fig. 10, is employed the inner tube

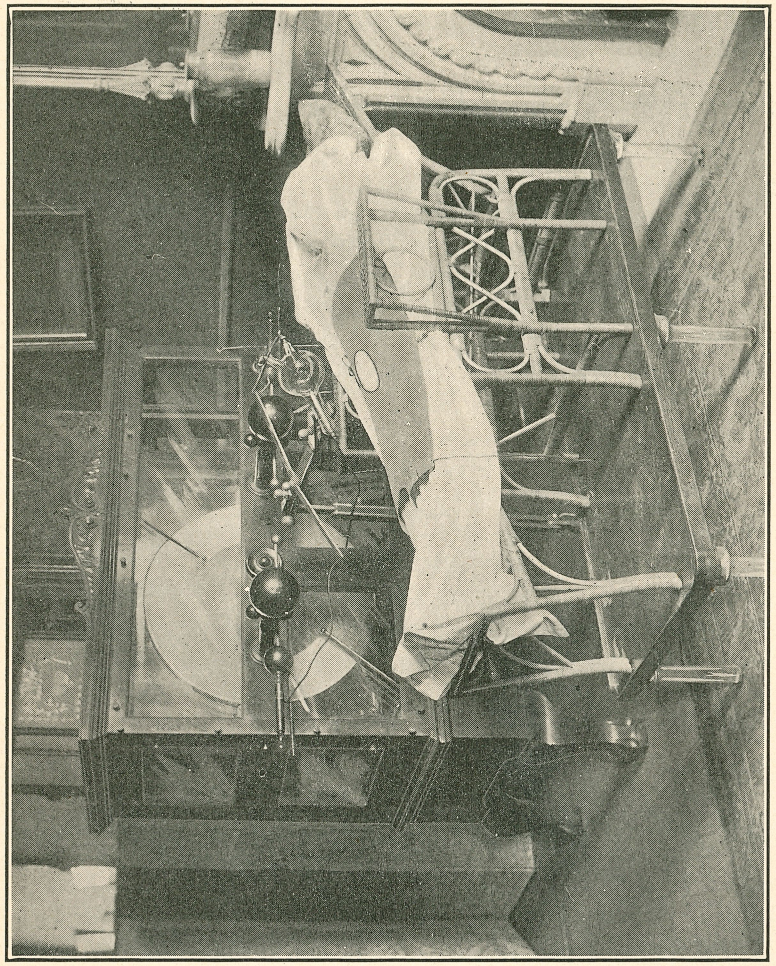


PLATE XI.—Method of Raying Cancer of the Pelvis from above the Pubis, the Anti-cathode Perpendicular to a Line Drawn through the Center of the Outlet. High-vacuum Tube Ten Inches from the Surface.

within the water bath may be covered except for one inch or one inch and a half from the extremity with a metal shield to prevent the escape of the rays except to the involved structures. The tube should be constructed of the thinnest glass at the anti-cathodal extremity, and the jacket should also be a very thin glass shell.

The writer has modified this tube in two particulars. The projecting portion of the tube is made of lead glass, except the last inch and a half at the extremity, and the jacket is fitted to the body of the tube by a ground-glass connection to avoid leakage and hold the jacket in position; the tape or rubber having so often become loose, and, at the same time, it did not hold the jacket away from the inner tube. When this tube is used it should be borne in mind that the X-rays evolved are induced in close proximity to the tissues, which necessitates shorter exposure. Five minutes is the generally accepted length of time admissible. It may, however, be shown to be of advantage to make longer exposures in the future, no recorded accidents having occurred from the five minutes' rule. With this type of tube it is impossible to energize it sufficiently to give any but low-vacuum effects without puncturing the anti-cathodal extremity of the tube, which is covered with the water-jacket to prevent the melting and puncturing of the glass. The jacket should, therefore, be kept filled during operation. The tube may either be placed in position and held by the usual stand tube-holder or held in the hands of the operator during the administration.

A modification of the Cossor tube used by the writer has the disadvantage of projecting only a small beam of X-radiance, and should be used for at least ten minutes, the operator moving it about in order to direct the rays in different directions, and thereby insure exposure to the involved structures.

The writer has found in these cases, when raying through the mouth, that the insulating shell has the advantage of preventing the induction and causing the uncomfortable sensations to the patient when it comes in contact with the teeth.

The Friedlander shield is similar to the Pennington, and composed of a material opaque to the X-ray. It is light in

weight and completely envelops the tube. It is constructed (Fig. 12) so that openings of different sizes enable the operator to focus the rays upon any desired spot or area. An advantage of this shield is that it is so constructed that sparks cannot jump across to the patient. The extension of hard rubber allows close contact to the part treated without unpleasant sensations to the patient.

An objection to both the Friedlander and Pennington shields, as now made, is that they are so constructed that the most direct and greatest volume of rays perpendicular to the

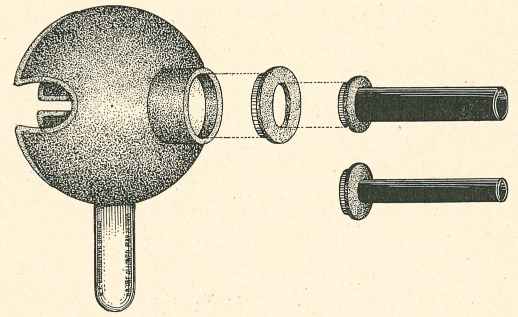


Fig. 12.—The Friedlander Shield.

anode are absorbed by the shield. This can be easily altered by placing the extension at the proper angle.

The two-cavity shields described above possess little advantage over the rubber composition shield and aluminum speculum (see Plate XI.), but may be preferred by some operators.

Systematic post-operative raying should be instituted as soon after the operation as the conditions will permit. If the union by first intention is delayed, it will be found that a few exposures of the X-ray will in most cases hasten the reparative process. The exposures should be made as prior to the operation. Twice weekly for prophylactic purposes will not be generally sufficient. The case should be watched for many months after the operation, and at the slightest indication of recurrence active raying should be instituted. The method is

on trial, and certainly offers additional encouragement for success in the treatment of this class of cases, in which the prognosis has been uniformly bad. The following case will illustrate the methods and results of treatment.

Mrs. B., aged fifty-five, came to me on August 6 with the history of having had pain for a year or more. At the time, she was feeble, and unable to come from her home in Brooklyn without an attendant. There was an offensive discharge from the uterus, and the organ was enlarged to nearly twice the normal size, but fairly movable. The diagnosis of malignant disease was made, and treatment with the X-ray instituted. Two exposures were made at each administration on alternate days—one through a speculum, and the other over the abdomen, as above described.

At the end of one week improvement was well marked. The discharge ceased to be offensive, and the patient's general health was materially improved. This treatment was kept up for six weeks, during which time she recovered her health, gained weight, and the discharge, which had entirely ceased for two weeks, had again appeared.

The uterus at this time was reduced to about one-half the size at the beginning of treatment. It was evident that the structures were breaking down under the influence of the ray, and that auto-infection would soon occur. An operation was accordingly advised, to which the patient submitted. It was performed by the writer's associate, Dr. Herman Grad, and the parts removed. It was found to be adherent to a loop of intestine; the rectum and bladder and the tissues were so friable that when separating the adhesion from the bladder the operator's fingers passed into the uterus. The operator accordingly found it necessary to remove the parts piecemeal, removing the cervical portion through the vagina. The vaginal wound healed promptly, the floor of the pelvis being completely closed within two weeks. The abdominal wound, however, healed less promptly, but with entire satisfaction. The patient is in perfect condition nine months after the operation, having been kept under constant observation. Clinically, the patient is cured; time only will determine the

permanency of the result. The accompanying drawing was made under the supervision of Dr. F. M. Jeffries from a microscopic specimen of the diseased organ. His report of the case follows. (See Plate XII.)

"Examination of the uterine tissue marked (Mrs. B.) reveals the following conditions:

"Uterus about the size of a nullipara. Cervix is missing and stump very ragged. Cavity slightly dilated, and presents numerous small projections. Entire organ is soft and spongy. Microscopically there is an extensive invasion of a mixed-celled sarcoma. The superficial structures both on the stump and within the uterine cavity have undergone extensive coagulation necrosis. The sarcoma cells have invaded the deeper portions of the muscular walls, and it is observed that the nuclei have undergone some sort of retrograde change, in that the chromatin filaments have broken up into minute granules, distributed evenly throughout the substance of the nuclei. From its nature I would assume that it is of a very malignant type."

Cancer of the rectum calls for the same general consideration as the preceding, except that the location renders an operative procedure much less satisfactory. The method of mercuric cataphoresis, instituted by Dr. G. Betton Massey of Philadelphia, offers more in these cases, when employed in conjunction with the X-ray, than the knife. The applications may be made high up in the cavity or in the region of the anus, and will be followed by sloughing away of all of the cancerous tissue without other unfavorable symptoms.

In these cases, a small jacketed cavity tube may be utilized for carrying the rays high up into the rectum. When the X-ray is employed in conjunction with surgery or the method of mercuric cataphoresis the prognosis will be fairly good.

Cases of cancer of the bladder may be treated as cancer of the uterus, raying above the uterus as well as employing the jacketed tube in the vagina. A small jacketed tube has been designed by Dr. Margaret A. Cleaves, which may be passed through the urethra and the exposures made directly

PLATE XII.—Microscopical Drawing Showing the Effects of the X-Ray upon Sarcoma of the Uterus. The Nuclei Have Undergone Some Sort of Retrograde Change in that the Chromatin Filaments Have Broken up into Minute Granules Distributed Evenly throughout the Substance of the Nuclei. Evidently, a Sarcoma of very Malignant Type.

to the inner coats of the bladder of the female. Not enough of these cases have been reported or treated to the present time to afford any basis for prognosis. The prognosis is generally bad, but will always be relative to the extent of the lesion and method of treatment.

CHAPTER V.

THE X-RAY AND ACCESSORY MEASURES IN AFFECTIONS OF THE SKIN.

The peculiar actions of the X-ray upon the skin are as follows:

I. Characteristic contractions on protoplasmic structures are produced, as shown in the chapter on Physiological Actions. The arterioles contracting deprive the skin of the usual blood supply.

II. The hair follicles and sweat glands, partaking of the same action, become functionally inactive, and, at the same time, are impaired by the cutting off of the nutrition furnished by the normal blood supply.

III. When the exposures are continued for successive short periods, or when a prolonged exposure is made, the glands and hair follicles become atrophied. This condition of suspended activity when followed by discontinuance of the exposures recovers in most cases after varying periods. The hands of physicians, however, who have exposed themselves frequently and for long periods to the X-ray, become painfully affected from the inactivity of the sweat glands thus induced, and the small hairs upon the hands fail to return, indicating a complete destruction of the hair follicles.

That nature is disposed to restore all such functions after periods of rest is shown in the restoration of the normal growth of hair and recovery of the functions of the sweat glands in most cases, which have been affected during a course of treatment for epithelioma or rodent ulcer. That the continuance of the use of the X-ray will ultimately destroy the possibility of the restoration of the functions of both hair follicles and sweat glands cannot be doubted. It seems, however, to be established that partial or complete restoration of those two sets of organs is most likely to take place in the

sweat glands, and that the hair follicles are first actually destroyed by X-ray exposures.

IV. The atrophy which takes place in the other structures of the skin is well marked from the thinning of the corium, leaving a peculiarly soft and delicate condition of the skin without scarring or other noticeable defect.

The writer has observed this condition particularly in a case of lupus erythematosus, which has been given six periods of raying during the past year, each time with the production of a slight dermatitis. The skin of this patient is absolutely free from hairs, is soft and peculiarly thin. It preserves, however, in other respects a normal appearance, not being unduly pale, as might be supposed from the contraction of the capillaries which takes place, which is probably because the brush-discharge has been used during the treatment of the case, and to some extent preserved the superficial circulation of the skin.

V. Microscopically the above conditions are in all respects verified.

In the treatment of skin affections it is unnecessary to employ an X-radiance of the same intensity as in the treatment of deep, malignant growths for obvious reasons. The employment of low-vacuum tubes, which give a dark shadow of the bones upon the fluoroscope, placed at a distance of six to eight inches from the anti-cathode, will generally prove satisfactory. It is not necessary, however, to obtain good results with the local conditions, that low tubes be employed, because high tubes will accomplish the same purpose. Penetration not being a requisite in these cases, the high-vacuum tubes unnecessarily affect deeper structures, and are on general principles contraindicated when effects upon only the superficial structures are necessary.

Acne of either the pustular or simple type is more promptly cured by the X-ray than by any other method. Success does not demand the employment of the X-ray to the extent of producing a severe dermatitis.

Screening in the treatment of acne is a matter of particular importance, because to sacrifice the eyebrows, eye-

lashes, and hair in an effort to remove a facial blemish would detract from instead of improving the cosmetic effects. (See Plate XII.) When the infection involves only the forehead and front of the face, one exposure at a sitting will be sufficient. In most cases, however, it is best to make two exposures, if for no other reason than that the prominence of the nose, with repeated exposures close enough to affect the sides of the face, brings that organ so near the X-ray tube that it is liable to suffer from marked dermatitis before the parts demanding treatment derive the necessary effect. If, however, exposures are made from the front, the nose should be screened. With female patients who have an abundant growth of hair upon the face the hair which soon replaces it after the X-ray exposures are discontinued will be coarser and it is also apt to be of darker color. Therefore screen the upper lip and sides of the face when superfluous hairs are found to be present.

To screen the eyes and eyebrows, cut a piece of soft metal to fit above the nose and large enough to cover the parts, and secure it with a piece of tape. A soft metal shield should be placed above the forehead and over the ears, and, at the same time, a shield of the soft rubber composition should be so placed as to protect the chest and shoulders of the patient.

The exposures should be made with the tube placed in such a position that the plane of the anti-cathode will be relatively parallel to the surface exposed, and at a distance of six to eight inches when employing a low-vacuum tube, or ten to twenty inches if a high-vacuum tube is used. The exposure should be for ten minutes on alternate days for the first five exposures, after which exposures may be continued twice weekly until a slight blush appears, indicating a commencing dermatitis, or, if no blush occurs, until the affection disappears. It may, however, be necessary in exceptional cases to make the exposures on alternate days again for a second and longer period in order to obtain satisfactory results.

After the first dermatitis does appear, it may not be necessary to make any subsequent exposures. If, however, the affection is not cured, successive periods of exposure should be made until a satisfactory result is finally effected.

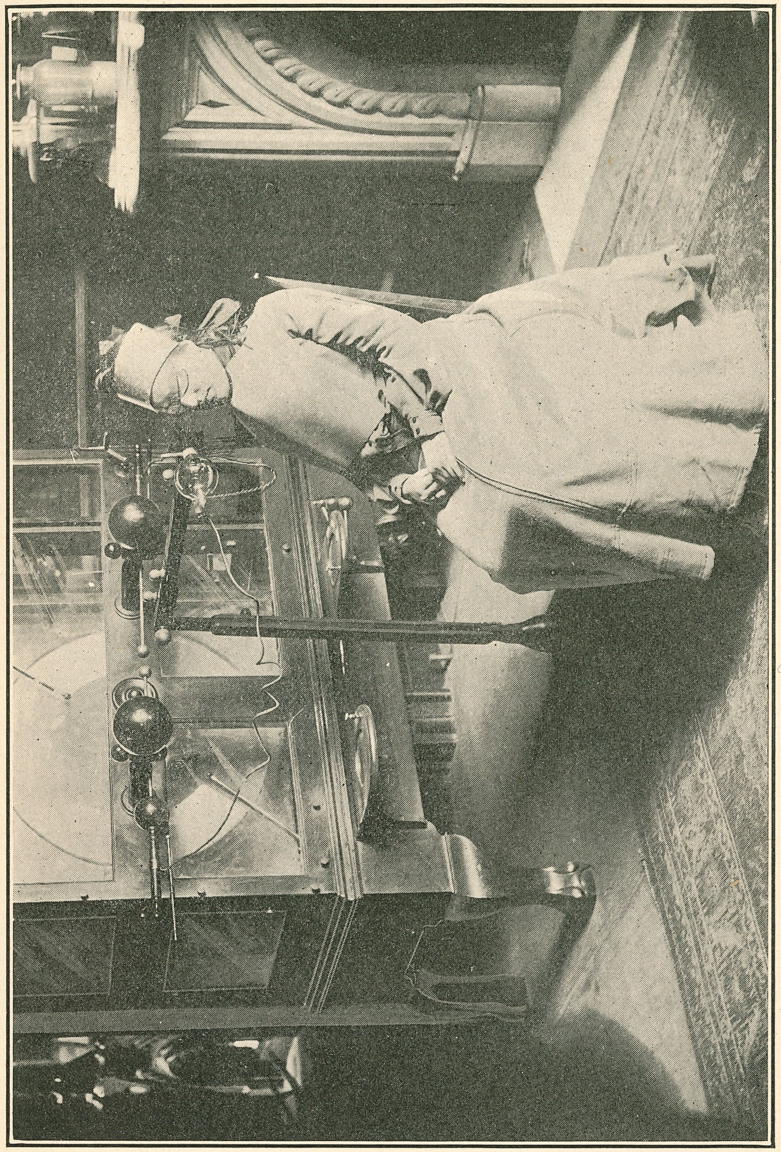


PLATE XIII.—Method of Screening when Treating Acne of the Face. Soft Metal Screens over the Eyes, Eye-brows, and Screening the Head to the Margin of the Hair. Rubber Composition Shield over the Chest.

In the intervals between the series of exposures the high-frequency glass electrode should be applied to the surface for its stimulating effect, thereby restoring the normal circulation to the superficial structures of the skin. There is no reason to believe that this plan of treatment should be followed by any unfavorable effects.

The vacuum-tube application is to be preferred in these cases to the brush-discharge, as the latter will produce a roughened and thickened condition of the surface if used for a long time.

The promptness with which the pustules cease to form during a course of X-ray treatment is a source of satisfaction and reassures the patient as to the ultimate success of the treatment.

The following cases will illustrate the results of treatment in which the above method was employed.

Miss C., a case of acne of three years' standing, in which all other methods of treatment had failed, characterized by the presence of deep pustules covering the sides of the face, chin, and forehead. She was treated for six weeks daily with the brush-discharge, with the result of lessening in a small degree the tendency of new pustules to form, but the method promised so little that the X-ray was substituted. After the first five exposures, which were given on alternate days, no new pustules formed, and at the end of three weeks a slight dermatitis appeared, and the treatment was suspended for ten days, after which the treatment was resumed twice weekly, and at the end of two weeks disconinued, the disfigurement having entirely disappeared. There has been no recurrence of the trouble two years after discontinuance of the treatment.

Mr. F., a case of the same type as the preceding, covering the back of the neck and shoulders, in which the affection had been present for two years, and had stubbornly resisted other treatment. The X-ray exposures were made for six times on alternate days, after which twice weekly. Dermatitis did not appear in this case to the end of six weeks, when every indication of the disease had disappeared. It is now eighteen

months since the treatment has been discontinued, and there has been no indication of its recurrence.

Case 3, Miss S., a case of simple acne covering both cheeks and forehead, was exposed to the X-ray and the brush-discharge administered on alternate days for three weeks; at the end of this time a slight dermatitis appeared, and the raying was discontinued, but the brush-discharge was employed as before. At the end of four weeks there were no pimples present, but the skin had a roughened and scaly appearance. The brush-discharge was then discontinued, and the face rayed twice weekly, when, after two weeks' treatment, all indications of the trouble had disappeared.

This case demonstrated to the writer's satisfaction that these cases are best treated without the employment of the brush-discharge. It has, however, been since demonstrated in the treatment of other affections that the glass vacuum tube electrodes are beneficial in stimulating the normal circulation, and thereby offsetting the tendency of the X-ray to produce an unnatural paleness to the surface.

The removal of superfluous hairs by the X-ray, as shown in the effects upon the hair follicles resulting when treating other pathological conditions, is naturally successfully accomplished but must be repeated many times to be finally successful, and on the whole is not to be recommended. The process, if to be employed, must be pursued in much the same method as in the treatment of acne, making the exposures practically the same, and at the same intervals, always discontinuing the exposures for a time when a slight dermatitis appears, or when the hairs have dropped out, as they will in most cases after from four to eight weeks of exposures. The treatment should be then suspended until the hairs begin to reappear, as they will in from two to three months, when the treatment should be resumed and carried out as previously. If this plan is persevered in after a series of intervals, the hairs will finally cease to recur.

This method of treatment has the disadvantage over epilation of affecting the secretion of the sweat glands as well, but in most cases, after the final discontinuance of the treatment,

the sweat glands will recover their normal function, and the object sought be practically attained.

Sycosis can be promptly cured by the employment of the X-ray in connection with the use of the brush-discharge, the X-ray to be used more energetically than in the treatment of acne, it being desirable to induce an active first-degree dermatitis. The brush-discharge may be applied daily to the affected spots during the period of raying, continuing the application each time until the skin is distinctly red. Satisfactory results are obtained in most cases within a month.

Ulcers of all types will in most cases be promptly healed by the application of the brush-discharge. The applications should be made not alone to the ulcerated surface, but also to the entire indurated area surrounding the ulcer, which thereby overcome the local stasis and hasten recovery. The promptness with which these cases are healed under this plan of treatment will give satisfaction to those who have employed other measures in the past. Undoubtedly the employment of the X-ray twice weekly will assist in the treatment of these cases. It should never be sought, however, to obtain anything more than the stimulating effects of the X-ray.

Lupus vulgaris had until the adoption of the light treatment by Finsen generally resisted all former methods. It has been demonstrated within the last three years, however, that the X-ray associated with the brush-discharge, and in rare cases the accessory employment of the light rays, succeeds promptly in the treatment of all cases. Most cases can be cured with the X-ray without the addition of other measures. Again, enough cases have already been cured by the employment of the brush-discharge, without the aid of other measures, to establish its recognition as a valuable measure in the treatment of all cases.

The violet and ultra-violet rays will succeed in these cases, but require powerful currents or prolonged periods of exposure, and are, therefore, more expensive than the X-ray and brush-discharge. They are indispensable, however, in saving indurated areas of the affection on marginal surfaces, as the eyelid, lip, or lobe of the ear, when, if the X-ray were

employed, the part would break down and be sacrificed. The violet light will undoubtedly cure most cases of lupus vulgaris without the assistance of other means, but has the disadvantage of being a slow, tedious, and expensive process. It is best, then, when possible, to employ the X-ray in connection with the brush-discharge, except in cases associated with marginal indurated areas.

The brush-discharge in these cases in the writer's experience fails to successfully cope with the condition of deep induration.

The X-ray when employed in the treatment of lupus vul-

Fig. 13.—Lupus Vulgaris.

garis should be used on alternate days with exposures of from ten to fifteen minutes, usually employing a low-vacuum tube; that is, a tube with which the fingers cast a dark shadow upon the fluoroscope. The tube should be placed at a distance of

six to eight inches from the ulcerated surface. The surface should be screened close to the margin of the affection and exposures made until the affected surface shows a distinct breaking down, when the X-ray should be discontinued and the brush-discharge employed daily until the effects of the previous employment of the X-ray shall have subsided.

The brush-discharge should be vigorously applied, moving it constantly about over the affected surface until the

Fig. 14.—Result of Treatment with the Brush-Discharge.

healthy margin of the normal skin becomes distinctly red from the administration. If after two weeks of this treatment the surface still shows a marked degree of infection, the ray should be again employed as before, and followed by the brush-discharge. This plan, if pursued, will result, we believe, in curing the affection in the shortest possible time. If the affected area is small, and it is desired to remove it with

the least amount of scarring, the brush-discharge will effectually remove the trouble. In the picture shown in Fig. 13 the patient was treated on alternate days for six weeks with the brush-discharge with the result of absolutely relieving the trouble, as is shown in Fig. 14. In this case the skin is perfectly normal, and absolutely no scar remains over the region affected. The scar just beneath resulted from curettement and the employment of carbolic acid in a former treatment of the case. This same patient was treated on alternate days for the affection, as shown in Fig. 15, with the brush-discharge.

Fig. 15.—Lupus Vulgaris.

charge. The treatment was persisted in for five months with a marked improvement in all respects, except that the lobe of the ear remained thick and indurated, and tender to pressure. At the end of five months, four exposures were made to the

surface with the X-ray, as above, including the lobe of the ear, when a distinct reaction was produced, and the danger of destroying the affected portion of the ear was apparent. The ear was accordingly covered, and the remainder of the face subjected to three more exposures. In the meantime, the employment of the ultra-violet light daily from a condensing focus lens using from twenty-five to forty amperes for the arc

Fig. 16.—Showing Marked Improvement.

light was instituted. All induration has disappeared, the discoloration alone remaining (see Fig. 16). In this patient, the surfaces have never become ulcerated during the course of treatment. Otherwise, it would probably have been cured by the brush-discharge, because the antizymotic action would then have affected more deeply the diseased structures. The results in the treatment of this case, which had resisted all

measures since infancy, illustrate well the various features of the technique applicable to the treatment of lupus vulgaris.

Lupus erythematosus, of the two types of lupus, is less prompt to respond to the mixed X-ray, brush-discharge, and light treatment, but invariably yields. The management and prognosis as to ultimate recovery both are about the same as in the treatment of lupus vulgaris. It has been demonstrated in lupus erythematosus that the violet light will suc-

Fig. 17.—Lupus Erythematosus.

ceed in curing most, if not all cases; but it is also demonstrated that the combined employment of the X-ray and brush-discharge will effect the same results generally in a shorter period of time. On the other hand, when the affection involves marginal structures, which is less frequent than in lupus vulgaris, or when affecting the parts where it is desirable to preserve the hair, the violet light may be judiciously employed.

The case shown in Fig. 17 had been under treatment for

seventeen years in the clinics of the best specialists in New York, and steadily grown worse. When he first presented himself for treatment, the face was covered, as shown, with thick, indurated blotches. There were also three spots in the hair over the occipital region, and the margins of the ear were in an ulcerating condition, and had been already partially destroyed. The treatment by the brush-discharge was begun and kept up for five months, at the end of which time the X-ray was employed, and was at intervals during a period of nine months. In this time the patient had rapidly

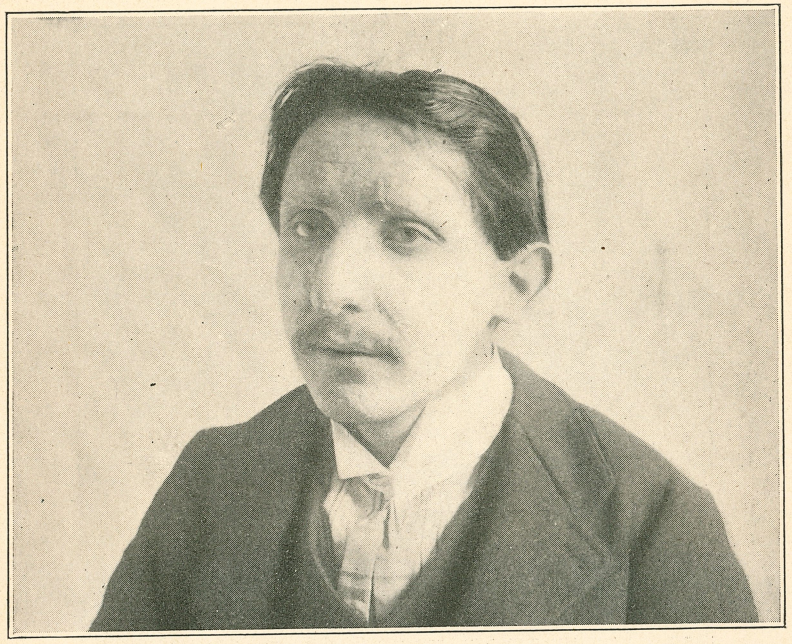


Fig. 18.—Result of Treatment.

improved, as shown in Fig. 18. During the application of the brush-discharge there was marked improvement. The ears, which were ulcerating and stiffened, became normal, and the thinner portions of the affection disappeared. It was not, however, until the X-ray was employed that the thicker in-

durated portions began to yield, showing the necessity of its employment. In the skin of the eyebrow of the left eye, in which the affection had already destroyed most of the hair follicles, it was deemed advisable to use the focused violet ray, and the results have been very satisfactory.

Exposures, however, were made for ten minutes every second day for at least six weeks before any marked improvement was manifest. At this rate it would have required many months of very prolonged exposures to effect a complete cure of the case. The X-rays in this case have never been pushed

Fig. 19.—Lupus Erythematosus.

to the point of inducing a breaking down nor to the extent of causing ulceration, and, except in a few instances, small scabs have formed upon the surface. In another case, shown in Fig. 19, the employment of the brush-discharge for six weeks

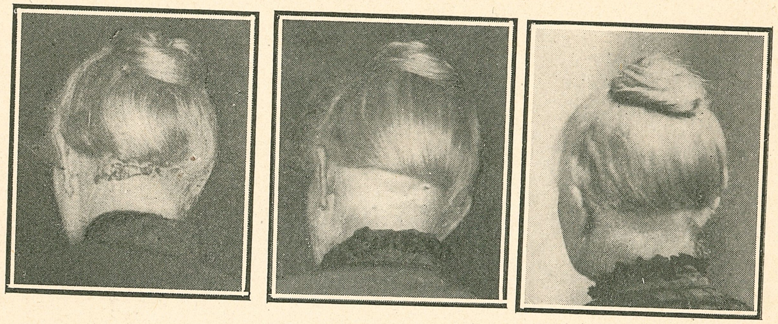
produced but slight improvement. The X-ray was then employed eight times on alternate days, as in the treatment of lupus. In all eight exposures were made, when the affected part broke down and sloughed profusely. During the sloughing, the brush-discharge was constantly employed, and in six weeks the surface was completely healed. It will be found, therefore, that under varying conditions the X-ray will affect the cases differently. We believe, however, that with the combined employment of the X-ray and brush-discharge, using the latter at each administration until a distinct rubefacient effect is produced upon the surrounding margins of normal skin, satisfactory results will be obtained in all cases, and in less time than from the light treatment.

The treatment of epithelioma by the X-ray is one of the greatest triumphs of this new agent. The success is already universally conceded, and we believe that under a judicious method of combined treatment the percentage of cures will include nearly all cases subjected to it. Here, as in the treatment of lupus vulgaris, the greatest measure of success will come from the employment of mixed methods, including the three modalities—light, X-ray, and the brush-discharge. Several cases of failure have been reported which we believe might have been successful under a different *modus operandi.*

Let it be borne in mind that the X-ray in these cases, as in the treatment of lupus vulgaris, is employed for the purpose of destroying the diseased tissue. It is accomplished probably by cutting off the blood supply by induced contraction of the capillary and arterial circulation. At the same time, the underlying and surrounding structures are subjected to the same action of the rays, producing in them a lowered state of nutrition, which if the process of raying is kept up indefinitely will not permit the restoration of the structures to a normal condition. We believe that many cases reported have failed to recover from the fact that the process of raying has been persisted in without reference to the peculiar action of the X-rays upon the diseased and surrounding structures. In most cases where very small areas are affected, the employment of the X-ray over a surrounding surface which

is well screened does not interfere with the possibilities of nutrition to such an extent that repair is interfered with, and these cases recover uniformly under exposures for periods of from six to eight weeks. When, however, a larger surface is affected and the rays are used, the results are often different unless other measures are employed, or prolonged periods of rest intervene in the course of treatment.

It is in these cases that the application of some antiseptic and stimulating measure as the brush-discharge has proved of so much value. The application of the brush-discharge, however, should be deferred until the tissues are breaking



Figs. 20, 21, 22.—Case of Epithelioma.

down, as they will in some cases, when there is invariably an appearance of lowered vitality. If employed in connection with the X-ray from the commencement of the treatment, its effects will retard the progress of the case.

The case shown in Figs. 20, 21, and 22 illustrates well the results of the judicious employment of the brush-discharge in connection with the X-ray. This case was of ten years' standing, having progressively increased to the condition shown in Fig. 20. The X-rays were employed on alternate days from a low-vacuum tube placed eight inches from the affected surface, the surrounding tissues having been screened. After eight exposures had been made the surface did not look so well as when the first exposure was made, and the surrounding margin of the skin showed an evidence of marked dermatitis. The exposures to the X-ray were then discontinued,

and the brush-discharge employed on alternate days to the end of six weeks from the date of the first X-ray exposure. At this time the appearance was as shown in Fig. 21. There were a few spots of induration along the site of the margin of the original opening, and also one point shown to the right in the cut which had probably been covered with the screens to some extent during the employment of the X-ray, and had not healed. The X-ray was then employed as before, seven exposures being made. The use of the brush-discharge was then again resumed for three weeks with the result as shown in Fig. 22. It is now two years since the last treatment of the case, and there is no sign of recurrence.

To the present time the writer has treated and cured fifteen other cases of epithelioma, in none of which there has been an indication of recurrence, and in no case has failure followed the treatment.

The case shown in Fig. 23 was a patient upon whom an operation had been performed eight months previously for epithelioma of the lip; an inch and a quarter of the lip had been removed, and the growth had returned. At the time the treatment was instituted there was an area of induration an inch and a quarter in diameter, and two lines in thickness at the thickest portion. The patient was unable to open his mouth sufficiently to take but the smallest portion of food, and it was difficult to determine whether it had not already involved the bone beneath the tumor. The X-ray was employed from a tube of medium vacuum on alternate days for five weeks, during which time remarkable improvement took place. A dermatitis had been set up and treatment was discontinued, the patient disappearing for three months. When he returned the central or thickest portion of the tumor had disappeared, and the whole mass presented a remarkable change. The induration at this time was most marked on the regions which had been screened during the exposures, showing the necessity of employing the screen judiciously in such cases. In this case it is evident that better results would have been obtained from the early treatment had the whole chin been exposed, and only the upper portion of the face been screened,

as was done subsequently in the management of the case. The patient made a progressive improvement toward recovery, and again disappeared. Another observation may be made from the results of this case, viz., that primary cases of epithelioma are more promptly cured than those which have been operated upon, and that the ulcerated surfaces permit more rapid removal of the condition than in cases in which the

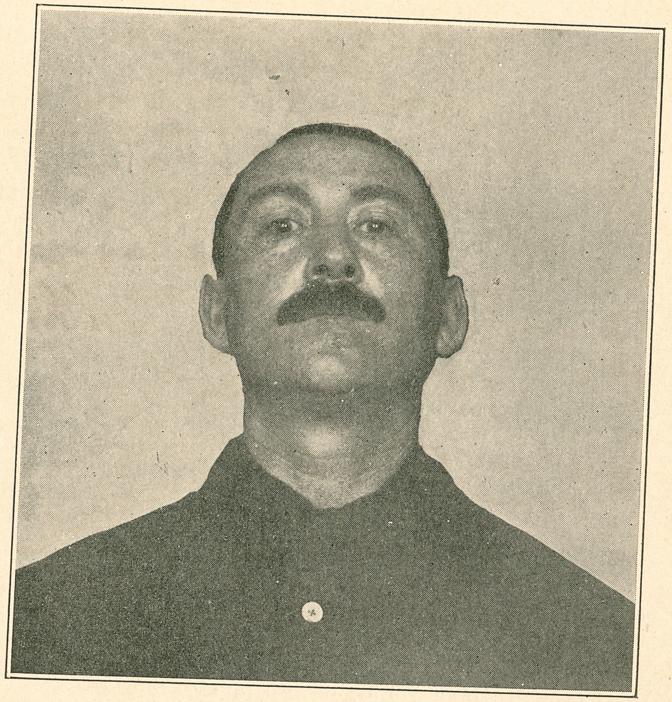


Fig. 23.—Epithelioma.

broken-down tissue must be removed by absorption. It will also be observed that an epithelioma which does not ulcerate with the possibility of the diseased tissue sloughing away may be satisfactorily absorbed, and disappear under exposures of the X-ray. A tube of higher vacuum will be required where the affected tissues are beneath the superficial layers of the skin, and not ulcerated.

Psoriasis is reported by many writers to have been favorably affected by X-ray treatment, and on general principles would be expected to improve. The writer has had good results from the employment of the brush-discharge, and to the present time has not employed the X-ray. If, however, the X-ray is used, it should be employed as in the treatment of acne, and the brush-discharge applied daily as soon as a slight indication of dermatitis appears. When employing the brush-discharge only, in the treatment of these cases, it is the writer's custom to make the applications daily over the affected area until a rubefacient effect is produced. It is not probable that any local treatment will entirely eradicate this chronic affection from the system of any patient. If, however, it relieves the local manifestations, it will be a satisfaction to the patient.

Eczema, like psoriasis, is probably a constitutional disorder, but the treatment of no affection will give greater satisfaction to the physician than the treatment of eczema by the combined employment of the X-ray and the brush-discharge. Many cases have been clinically cured by the employment of the brush-discharge alone. The pruritus is usually relieved by the first local application, and all types of the affection are cured if the treatment is persisted in. The employment of the X-ray in connection with the brush-discharge hastens the ultimate recovery. It should never be employed, however, oftener than twice weekly, and if possible no dermatitis whatever should be induced. To avoid this, make ten-minute exposures with a medium vacuum tube at a distance of twelve to fifteen inches, at the same time give daily administrations of the brush-discharge until the affection has entirely disappeared.

Keloids respond better to X-ray treatment only. Remarkable results have been obtained in many cases. The rays here should be used as in the treatment of epithelioma, following up the procedure until dermatitis appears. In many cases the result is all that could be desired.

Herpes is strictly a form of neuritis and yields to either the wave-current or brush-discharge, and may be slightly hastened by applications of the X-ray, as described in the treat-

ment of acne. Here, as in the management of eczema, the administration by both measures conjointly is indicated from the commencement of the treatment.

The static applications in herpes should be made daily until the eruption and pain have disappeared. If treated before the stage of eruption in most cases it will not occur.

CHAPTER VI.

THE X-RAY TREATMENT OF CONDITIONS CHARACTERIZED BY DISTURBANCES OF METABOLISM.

THE action of the X-ray upon nutritive processes of a tonic character is a subject deserving thoughtful study.

The classes of cases characterized by conditions of altered metabolism include inflammatory processes, both acute and chronic, in all of which, except the specific, vibratory influences properly administered have a potent effect toward the re-establishment of normal conditions. Certain specific affections also which arise on account of the lowered conditions of vitality, as tuberculosis, may also be benefited by the vibratory effects upon nutrition associated with the induction of a more active metabolism. The action of the X-ray is first to stimulate local conditions, which effect is marked when applied for short periods at a distance relative to the intensity of the ray employed, a greater distance being employed with tubes of high vacuum.

It must be understood in order to appreciate the different actions of X-rays, that excited under varying conditions the qualities and characteristics vary as the musical scale. In other words, the range at which the radiation is evidenced by its effect upon the fluoroscopic screen, from the low-vacuum tube, which will not show the bones of the hand, to the extreme penetrating radiance of X-rays from a high-vacuum tube when produced by an energizing source of great intensity, constitutes variations *more* numerous than the musical scale.

Experience teaches that tissues may be stimulated to increased functional activity or inhibited to the extremity of producing necrosis and death of the tissues by the Roentgen ray.

The destructive action of the X-ray occurring after long exposures with low-vacuum tubes under intense currents of large quantity, or of high-vacuum tubes similarly excited, has

been demonstrated to produce curative effects under proper regulation.

In the class of conditions under consideration it is the short exposure with a high-vacuum tube, stimulating in character, which induces tonic conditions with restored metabolic activity, which has proved of great value.

Inflammatory conditions are influenced by the induction of contraction by the rays, restoring tone, increasing circulatory activity, and thereby overcoming local stasis. In order, however, to maintain a tonic condition and not produce the extreme inhibitory effect of the action, which so far diminishes the lumen of the arterioles as to produce local anæmia in the tissues, requires a careful discrimination on the part of the operator. High-vacuum tubes placed at a distance of fifteen to twenty inches from the tissues are best for this purpose. The exposures in these cases may be made on alternate days, but in most cases two treatments weekly will be sufficient. The study of the cumulative action and the requirements to bridge effects is a subject of great interest with the X-ray as with static administration, because it will determine results.

Acute inflammatory conditions are often favorably affected by this plan of treatment. As a rule, however, better results are obtained with this class of cases from the static treatment, as shown in the preceding chapters of this work.

The effect of the X-ray upon inflammatory conditions is evidenced, as shown in a previous chapter, by the relief from pain which, in many cases, so promptly follows the exposure. The indications for its uses in inflammatory conditions are only in the class of cases to which the static modalities cannot be directly applied, as acute inflammatory conditions within the peritoneal cavity and chronic or acute conditions of the brain or spinal cord, in which it may be often difficult to demonstrate the efficiency of the static modalities, especially in obese and muscular adults, and also in deep facial neuritis. It may also be employed in cases in which the other modalities have failed. The principle of action upon which the improvement will be anticipated will be as stated above—the lessening of the lumen of the arterioles and increased metabolism,

thereby shutting off the congested process, and inducing a removal of local stasis. If, in these cases, the administrations can be bridged with proper discrimination, favorable results may be anticipated.

The following case will illustrate the principle: Mrs. ——— had suffered for eight years with chronic tic douloureux. Experience having taught the writer that the use of the static modalities in such cases is unsatisfactory, he, accordingly, determined to employ the X-ray. Four exposures were made at intervals of three days, employing a high-vacuum tube at twelve inches. After the second treatment, the pain had ceased, and ten months since the last exposure there had been no recurrence of the trouble.

There are numerous records of success from these exposures in the treatment of internal inflammatory conditions, as in chronic appendicitis. Fistulæ, which had been open for months or years, have been closed by this means. Incidentally, it has been reported by various authorities that sciatica, brachial neuritis, and other inflammatory conditions have been greatly relieved when exposed to the X-ray. In the writer's opinion, however, these conditions are always best treated by the static modalities, which are uniformly successful with the acute and chronic inflammatory conditions.

Locomotor ataxia has been treated recently by the employment of the X-ray, and the rationale of its action would indicate its use in treating the disease as an inflammatory process, which it undoubtedly is. In making the exposures for the treatment of tabes they should be made on alternate days, and it is the writer's custom to place the tube alternately over the lumbar vertebræ with the anti-cathode directed upward, and at the next exposure opposite the cervical or upper dorsal with the anti-cathode directed downward, the object being to project the rays from different directions with a view to effecting a more uniform exposure of the whole length of the cord. The exposures are made with high-vacuum tubes at a distance of from twelve to twenty inches from the trunk of the patient.

Tubercular affections when exposed to the X-ray should be

treated with a view to restoring normal physiological conditions, and improving the general resistance of the patient.

Pulmonary tuberculosis is reported in several instances to have been cured by the employment of the X-ray in conjunction with hygienic measures. The *modus operandi* should always include all other measures which contribute to the general health and improvement of the patient. The employment of static electricity, light, diet, outdoor exercise, and, possibly, inhalations of ozone should be considered in the treatment of every case. The X-ray in these patients is employed as a stimulating tonic for the improvement of the general conditions of the patient. The exposures should not on general principles be made oftener than twice weekly, employing a high-vacuum tube at a distance of from twelve to twenty inches. It should be borne in mind that the resistance of the tissues of tubercular patients is lowered, and that the X-ray employed incautiously is liable to produce a dermatitis which will increase, instead of diminishing, the chances of the patient's recovery.

In the treatment of tubercular joints there have been, undoubtedly, good results obtained from the employment of the Roentgen ray. The cases published, however, do not show conclusively what extent of exposure is demanded for the treatment of the condition. The writer has had experience in but few cases which lead to the conclusion that the effects are derived from the influence of the X-ray upon congestion, and the improvement of the local condition. The exposures should be made upon alternate days or twice weekly at a distance of twelve to twenty inches, employing a high-vacuum tube for the usual period of ten minutes, and never pushed to the extent of producing a local dermatitis. The prognosis will depend upon the extent of the invasion and the involvement of the bony and ligamentous structures of the joint.

When bone is already involved and cannot be removed surgically, it is impossible to expect to effect a satisfactory result. It is only then in cases where the involvement is slight that a favorable prognosis can be given, and in such it should always be guarded. The general principles of the employ-

ment of the X-ray for its tonic effect, as suggested in the treatment of the above conditions, will hold good in its applications to similar conditions, but there is not enough evidence at present to confirm the notion that it should be generally employed in lieu of other measures which have proved efficient.

It is probable that in most cases in which the X-ray is employed in the treatment of inflammatory conditions the proper application of the static modalities would produce infinitely better results.

Hodgkin's disease has been demonstrated by various observers to have been clinically cured by the employment of the X-ray. In these cases, the exposures should be made at a distance of from twelve to twenty inches, employing a medium- or high-vacuum tube for its tonic effect upon the structures. When treating, exposures should be made directly over the glands affected, and also over the trunk of the patient. This may be done upon alternate days, giving daily exposures, and taking care that the same portions of the body are not exposed on succeeding days. If the exposures are made at twenty inches from the body the danger of dermatitis will be slight, and with a high-vacuum tube the effect will be to favorably influence the condition.

Gumma tumors beneath the integument and possibly elsewhere may be demonstrated in the future to be amenable to local treatment by the X-ray. A case which recently came under the writer's observation in which the diagnosis of the tumors as of syphilitic origin were undoubtedly correct, one upon the upper end of the sternum, and extending for two inches upward upon and above the clavicle, and the other about two inches in length over the lower third of the tibia, promptly disappeared when exposed on alternate days for a short period —in all twelve exposures to the X-ray. These tumors were exposed with the anti-cathode placed at a distance of twenty inches from the integument over the tumors. No dermatitis was induced, and the tumors began to diminish after the second exposure.

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